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Cheung

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(54) **MECHANICAL VENTILATION SYSTEM AND DEVICE FOR FOOTWEAR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 245 days.

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(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/366,431, filed on Jul. 25, 2016.

(51) **Int. Cl.**

A43B 7/08 (2006.01)
A43B 13/18 (2006.01)
A43B 13/20 (2006.01)

(52) **U.S. Cl.**

CPC ***A43B 7/087*** (2013.01); ***A43B 7/081*** (2013.01); ***A43B 7/082*** (2013.01); ***A43B 13/185*** (2013.01); *A43B 13/20* (2013.01)

(58) **Field of Classification Search**

CPC A43B 7/081; A43B 7/082; A43B 7/87; A43B 7/06; A43B 7/146; A43B 13/20; A43B 13/203; A43B 13/206; A43B 13/181; A43B 13/182; A43B 13/185

See application file for complete search history.

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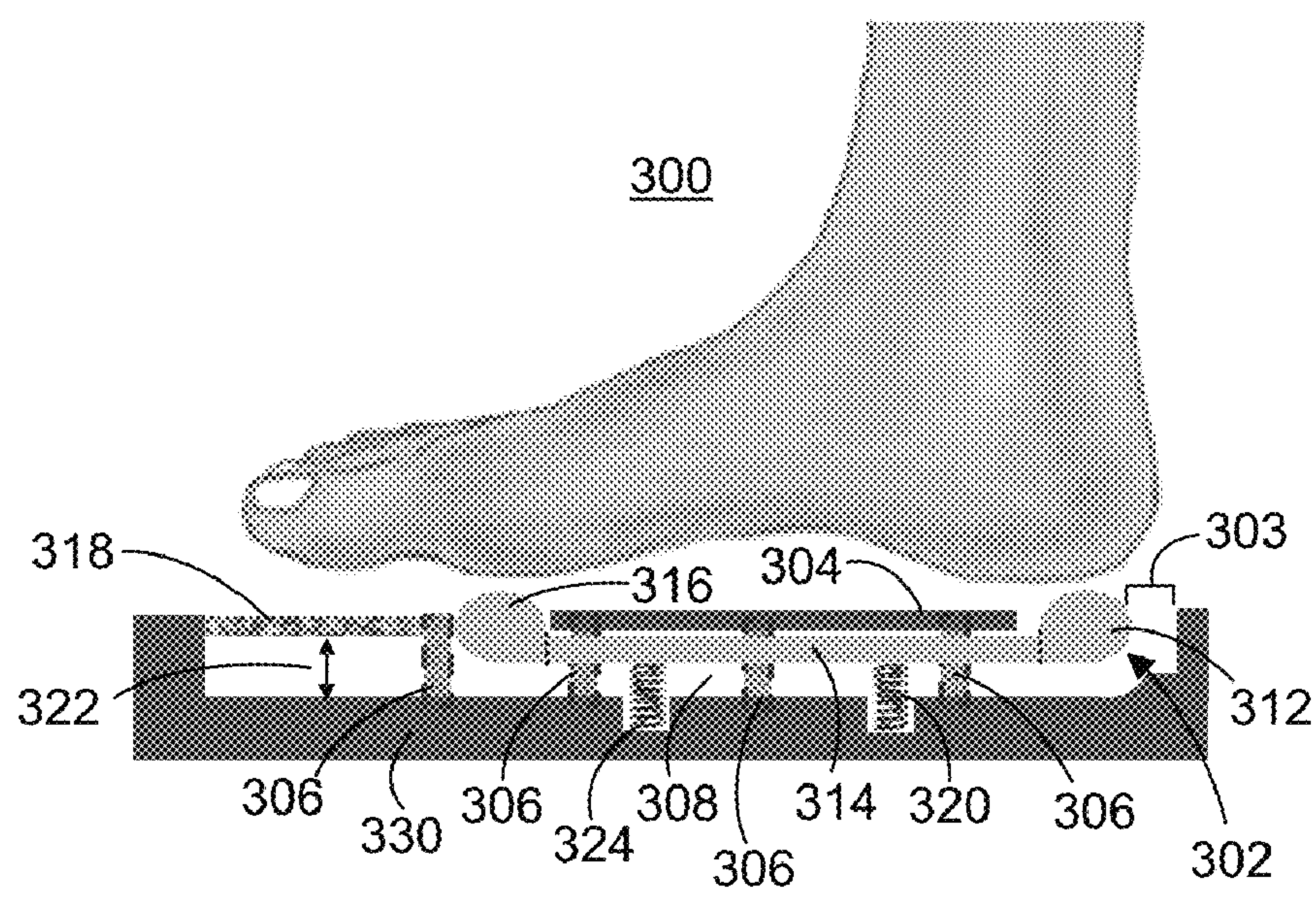
(57) **ABSTRACT**

Systems and devices are described for creating a more effective mechanical ventilation system for footwear. For example, a mechanical ventilation system can include an air reservoir that is almost as large as the entire shoe under the footwear's foot bed. In some examples, the air reservoir can be connected to an area that includes a foot of a user in the footwear. The air reservoir can be compressed using a movable part that circulates air in the footwear with every step. The movable part can be relatively small, extending into the air reservoir, and able to compress and inflate the air reservoir. Movement of the movable part can cause a large effective compressible area of the air reservoir to release fresh air near the toes of a foot to flush stale air out of the footwear.

20 Claims, 25 Drawing Sheets



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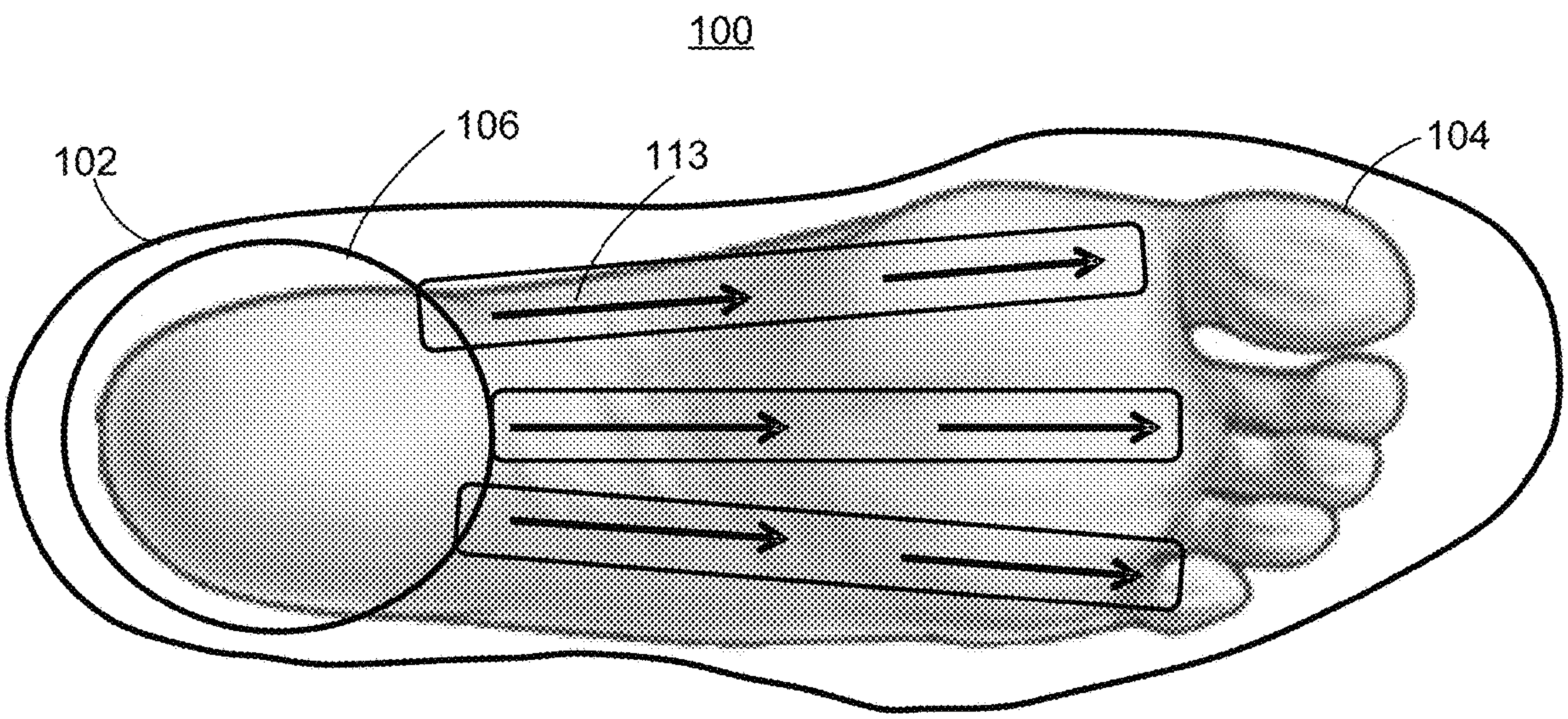

FIG. 1A

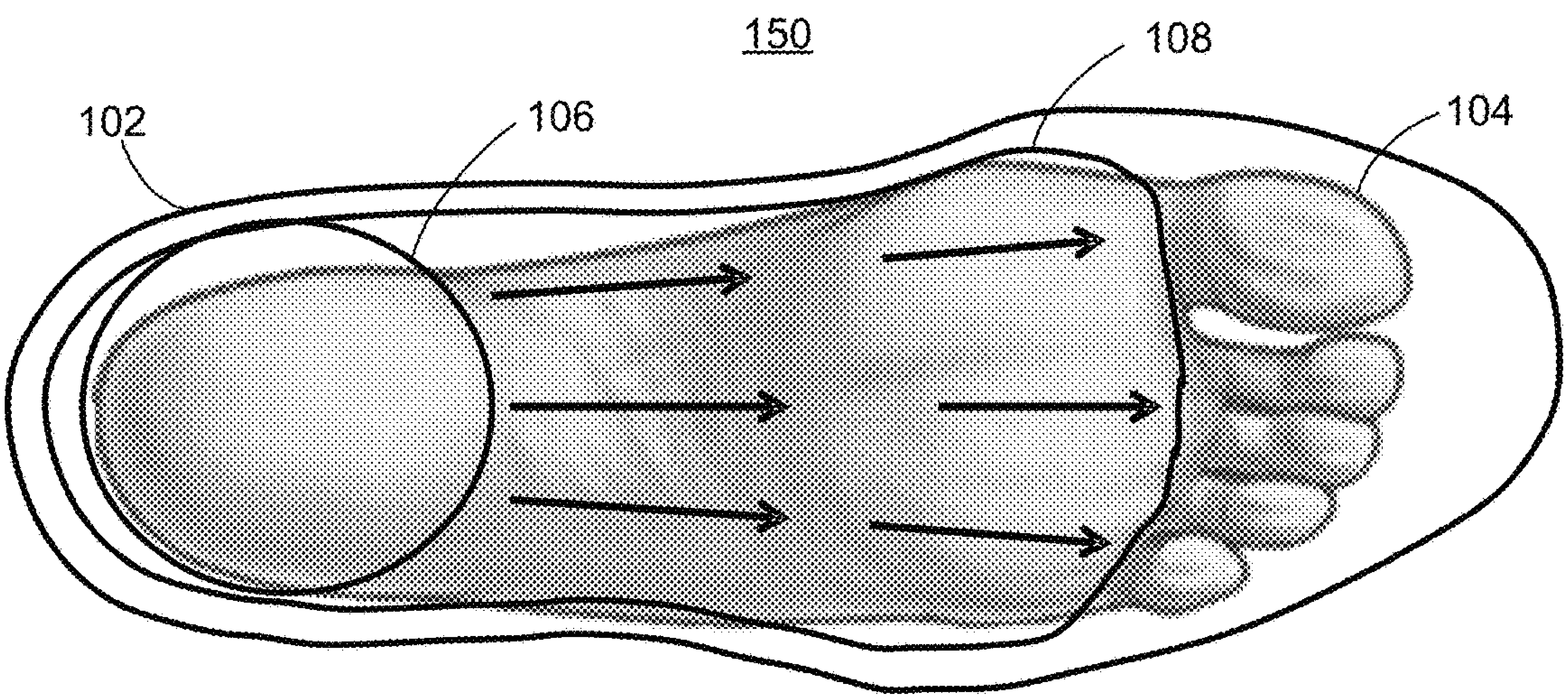

FIG. 1B

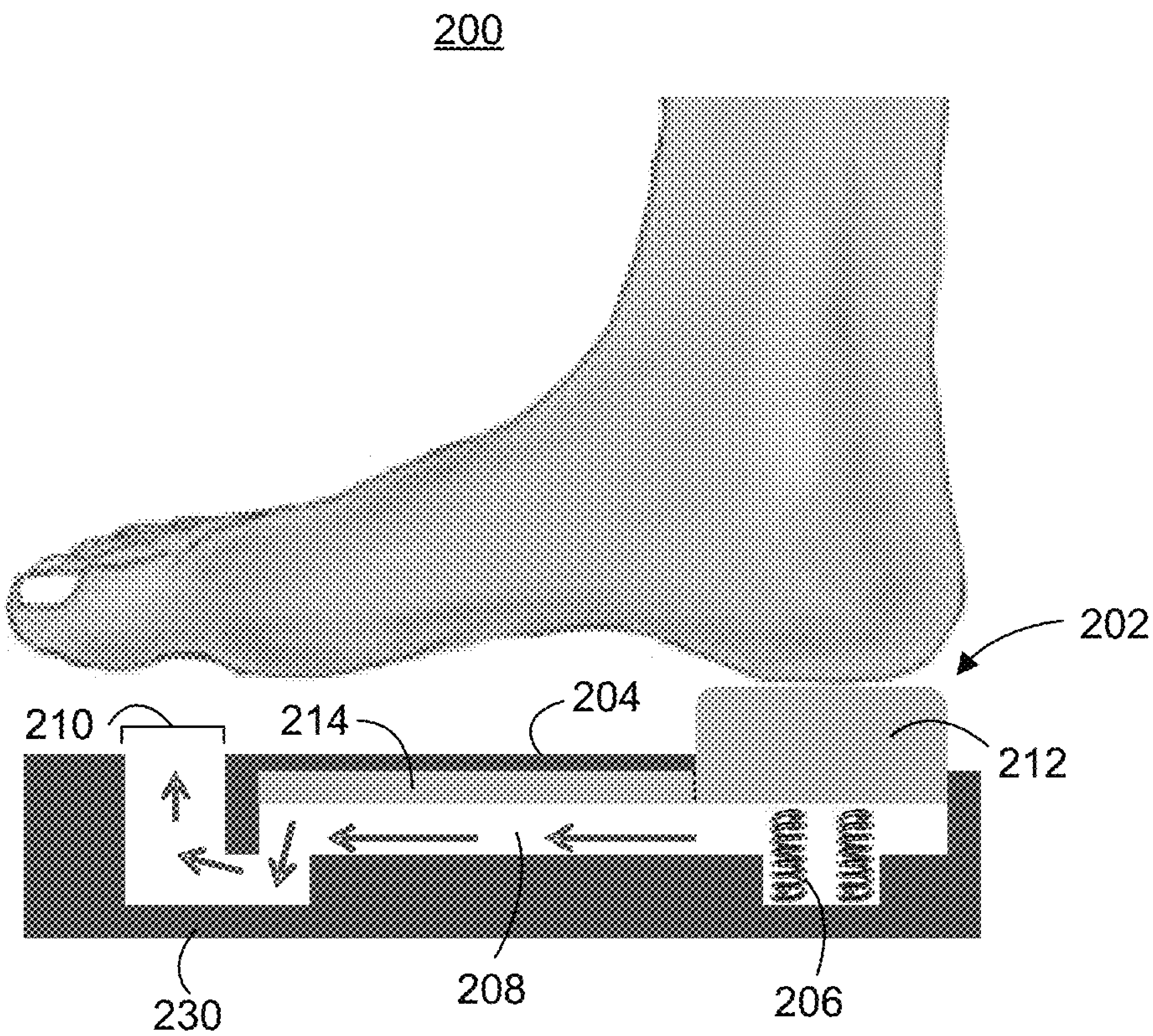

FIG. 2

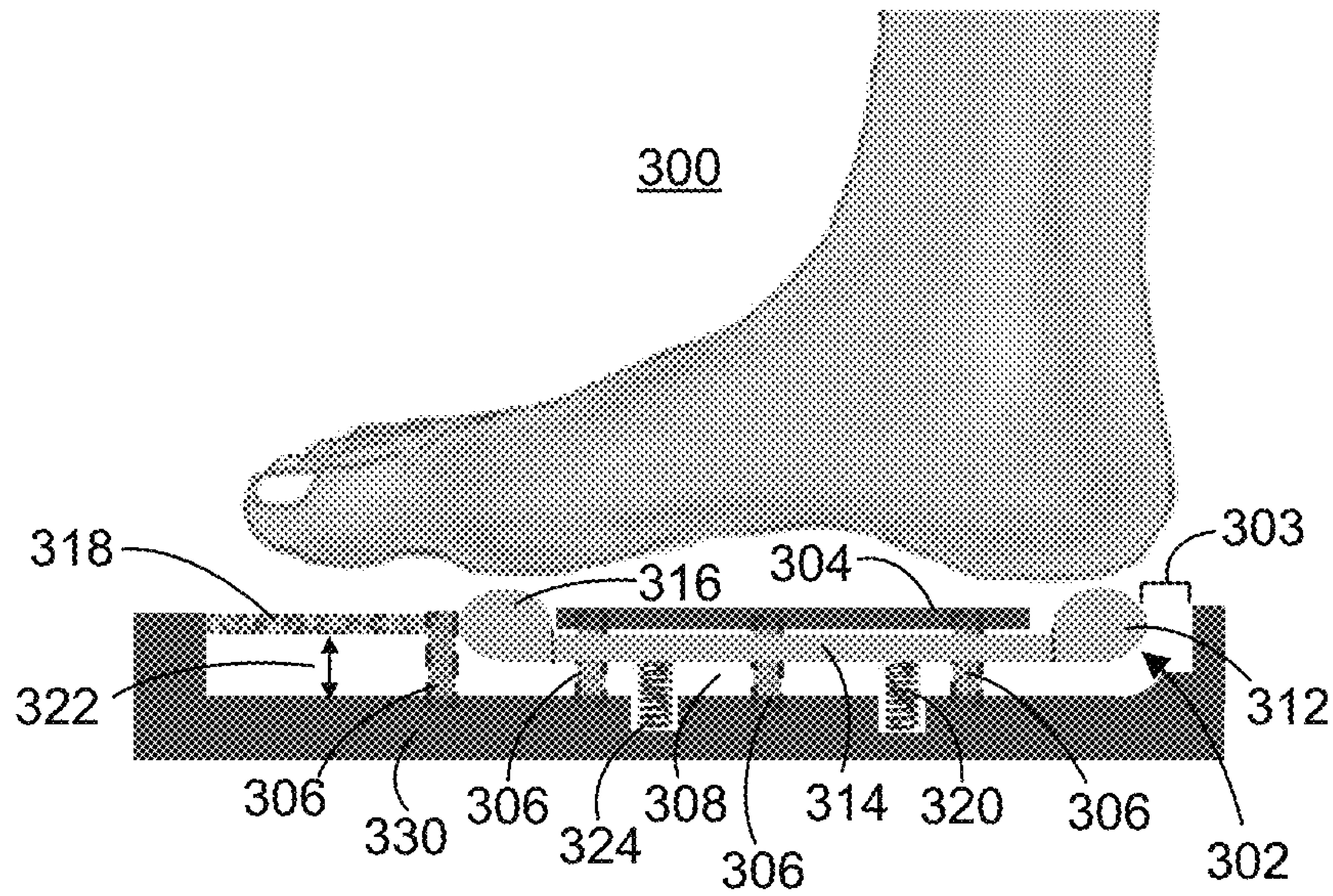
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FIG. 3A

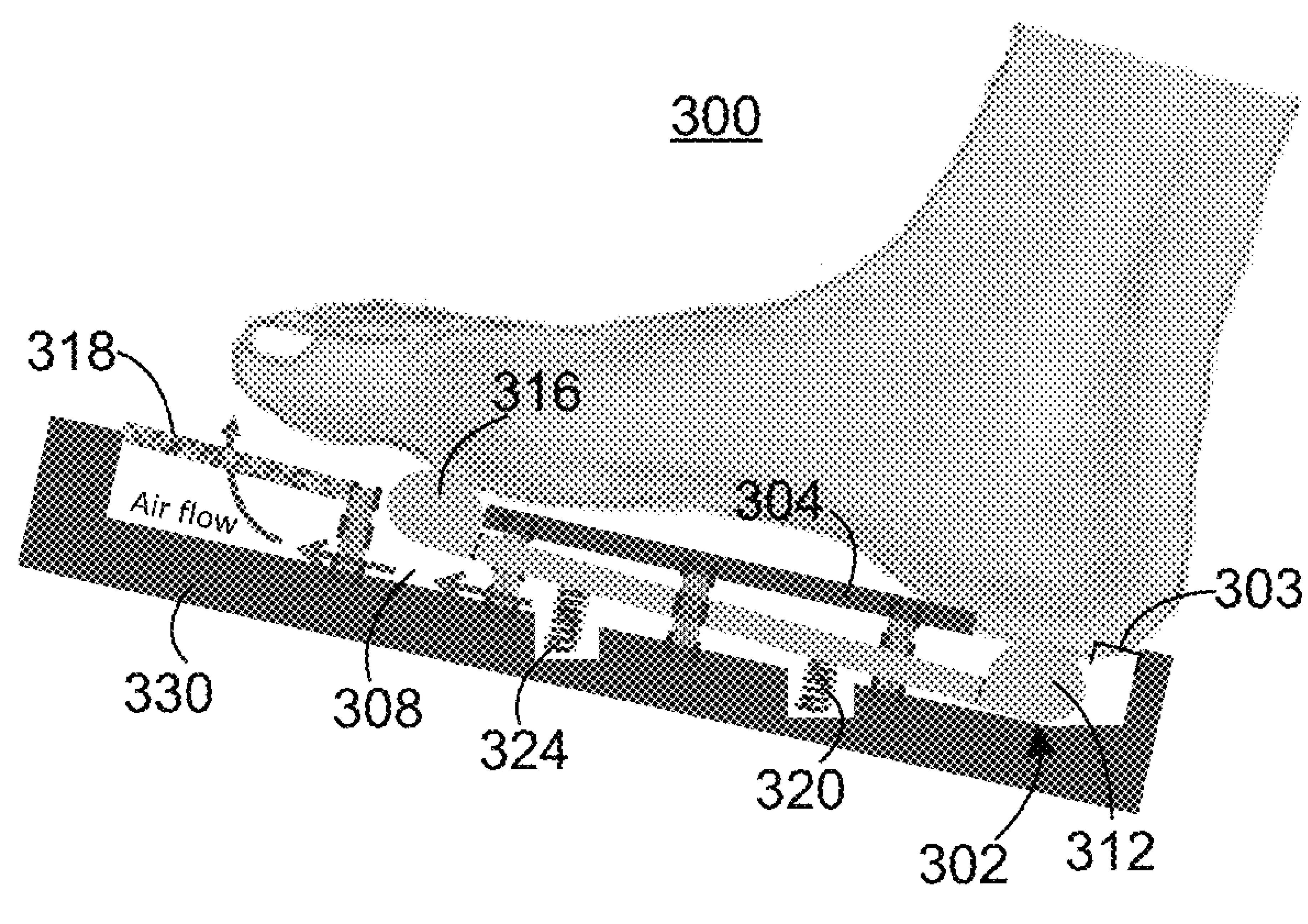
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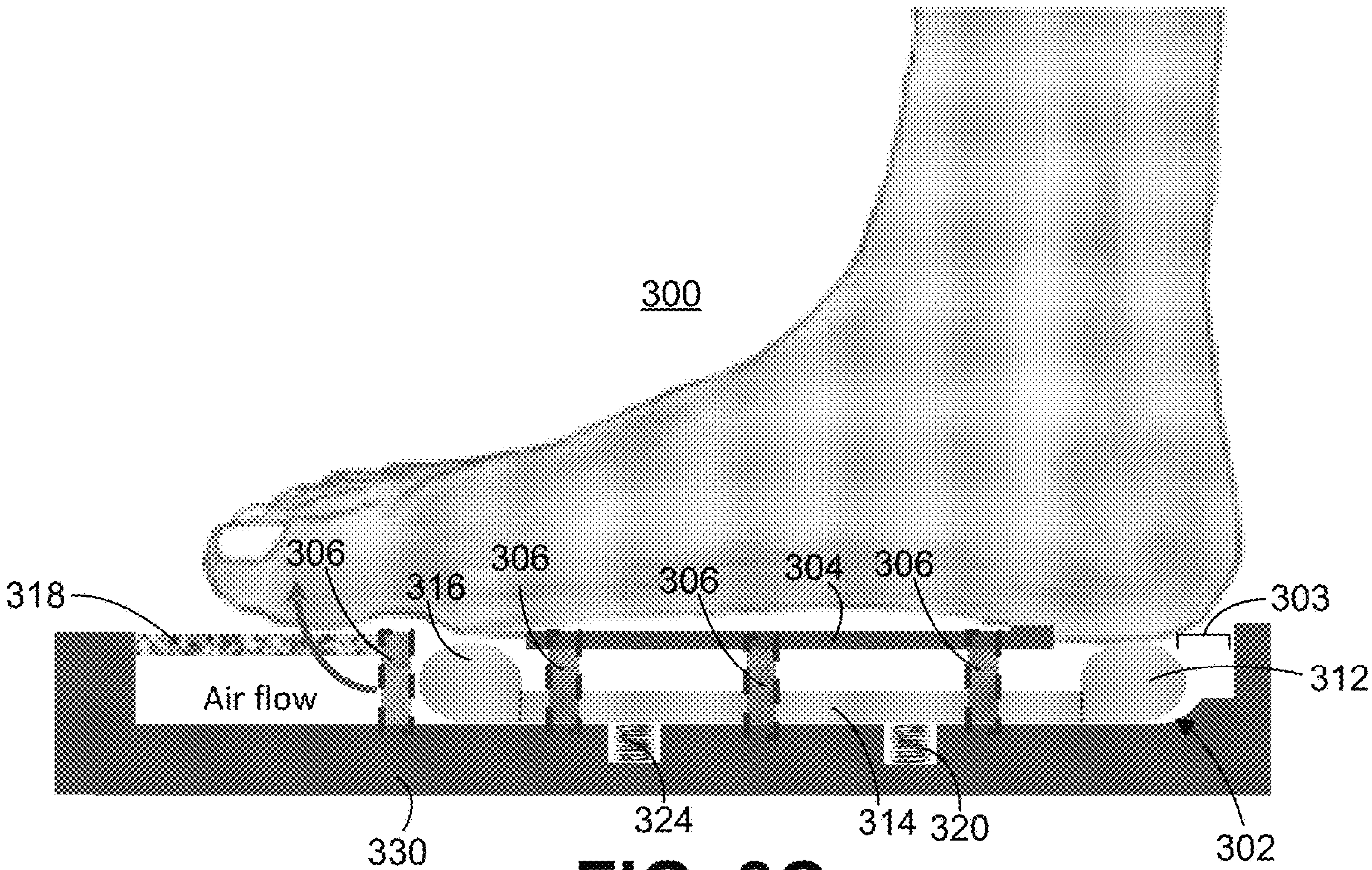
FIG. 3B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Air flow
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FIG. 3C

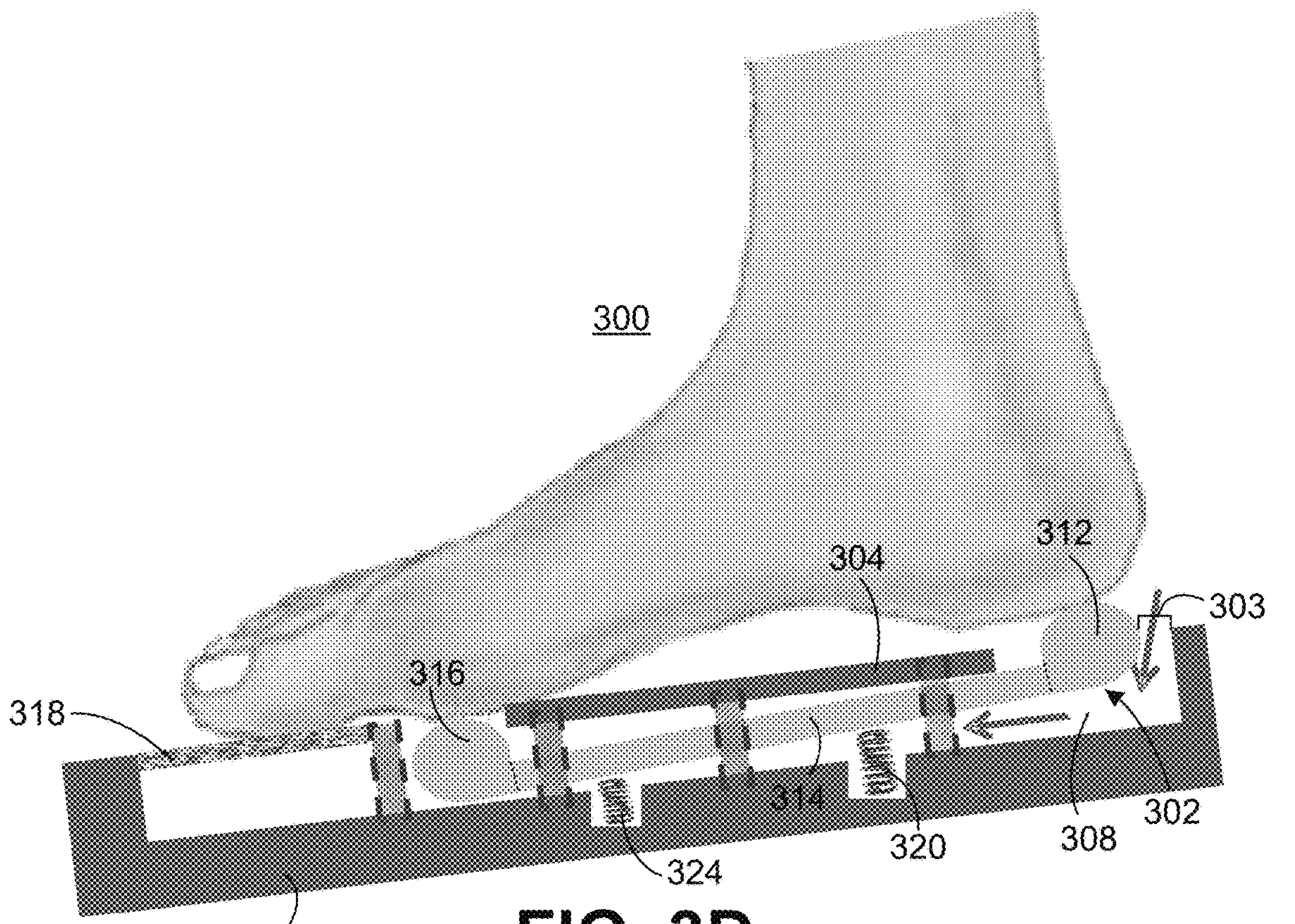
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FIG. 3D

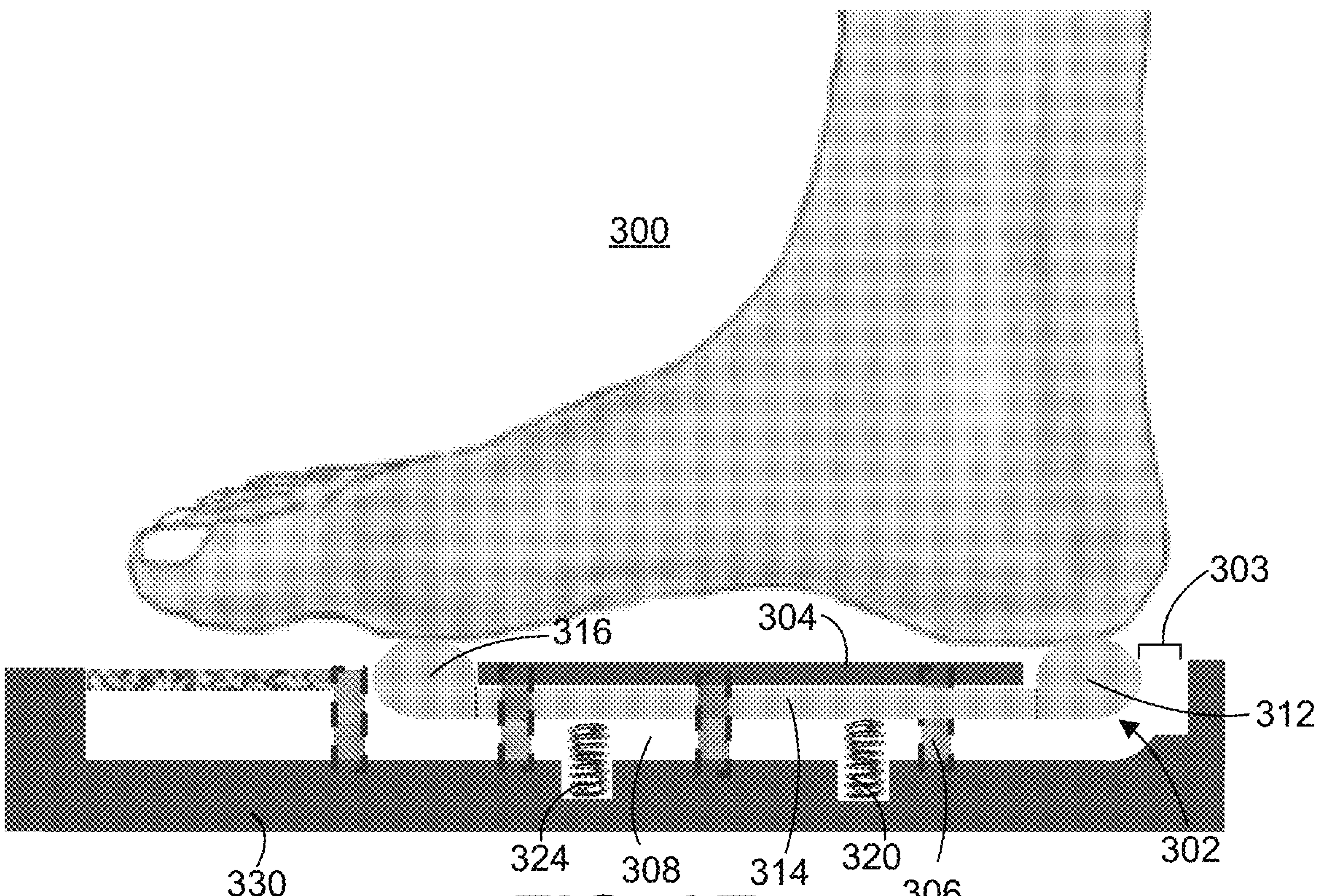

FIG. 3E

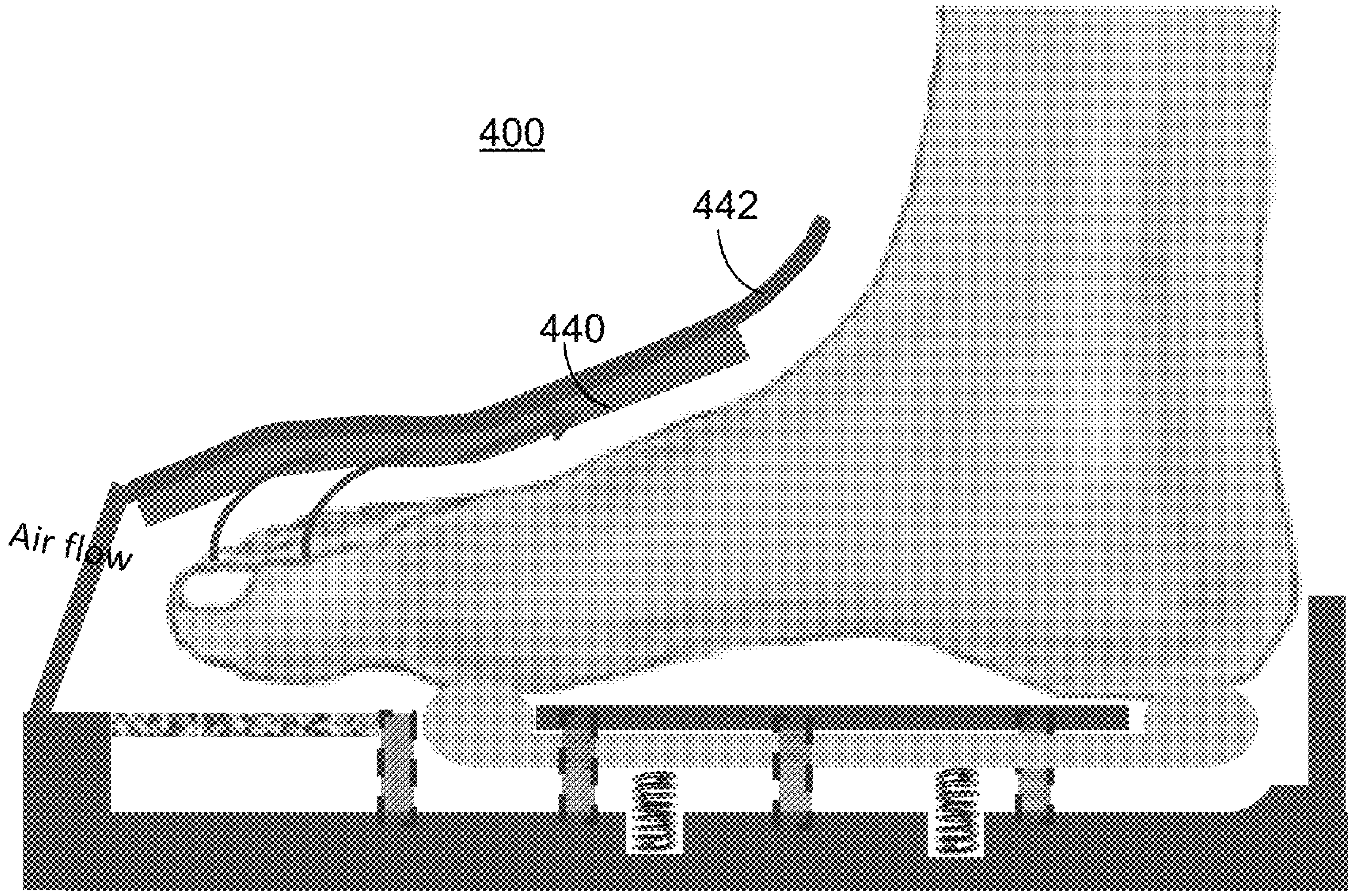

FIG. 4A

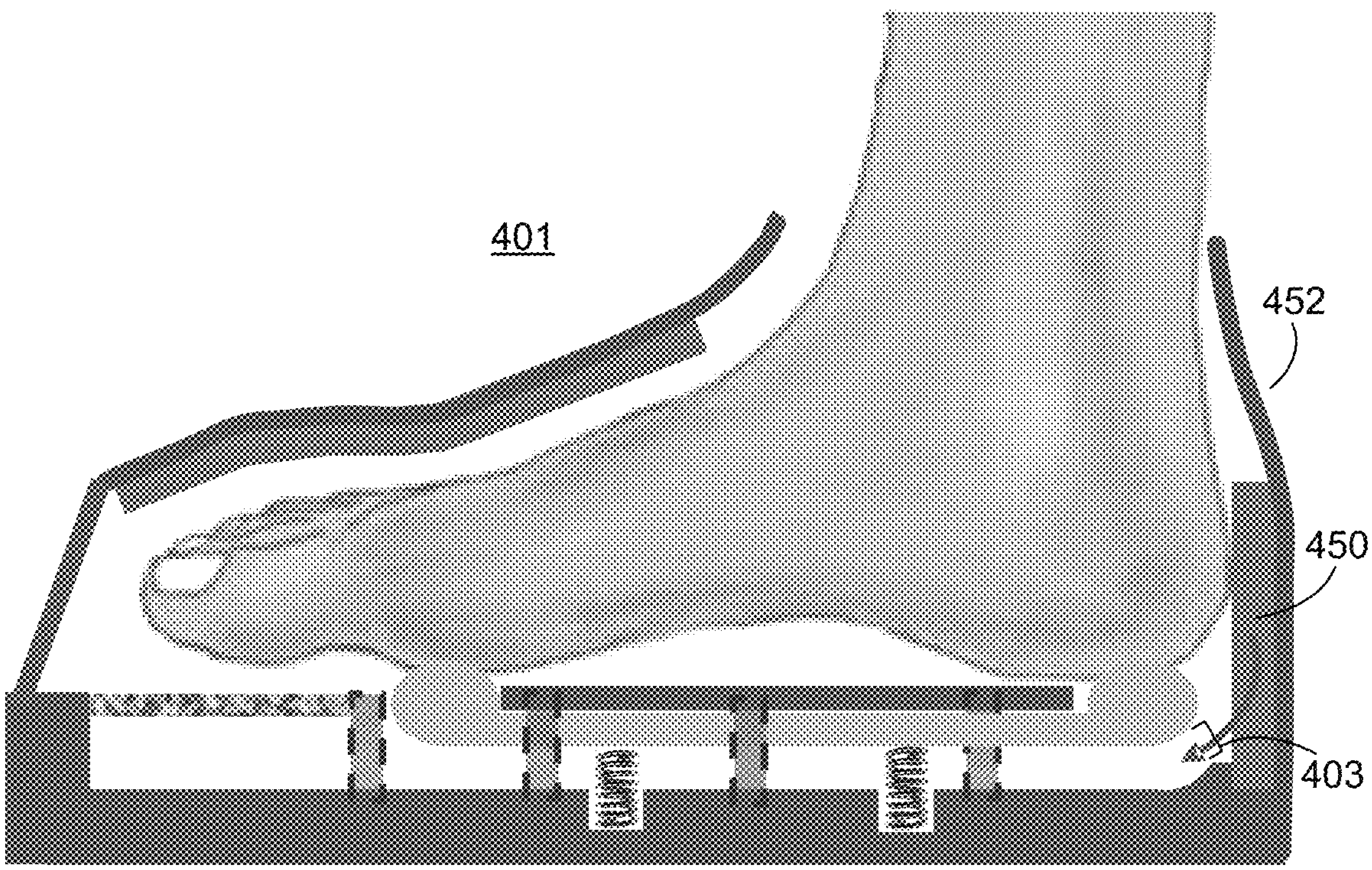

FIG. 4B

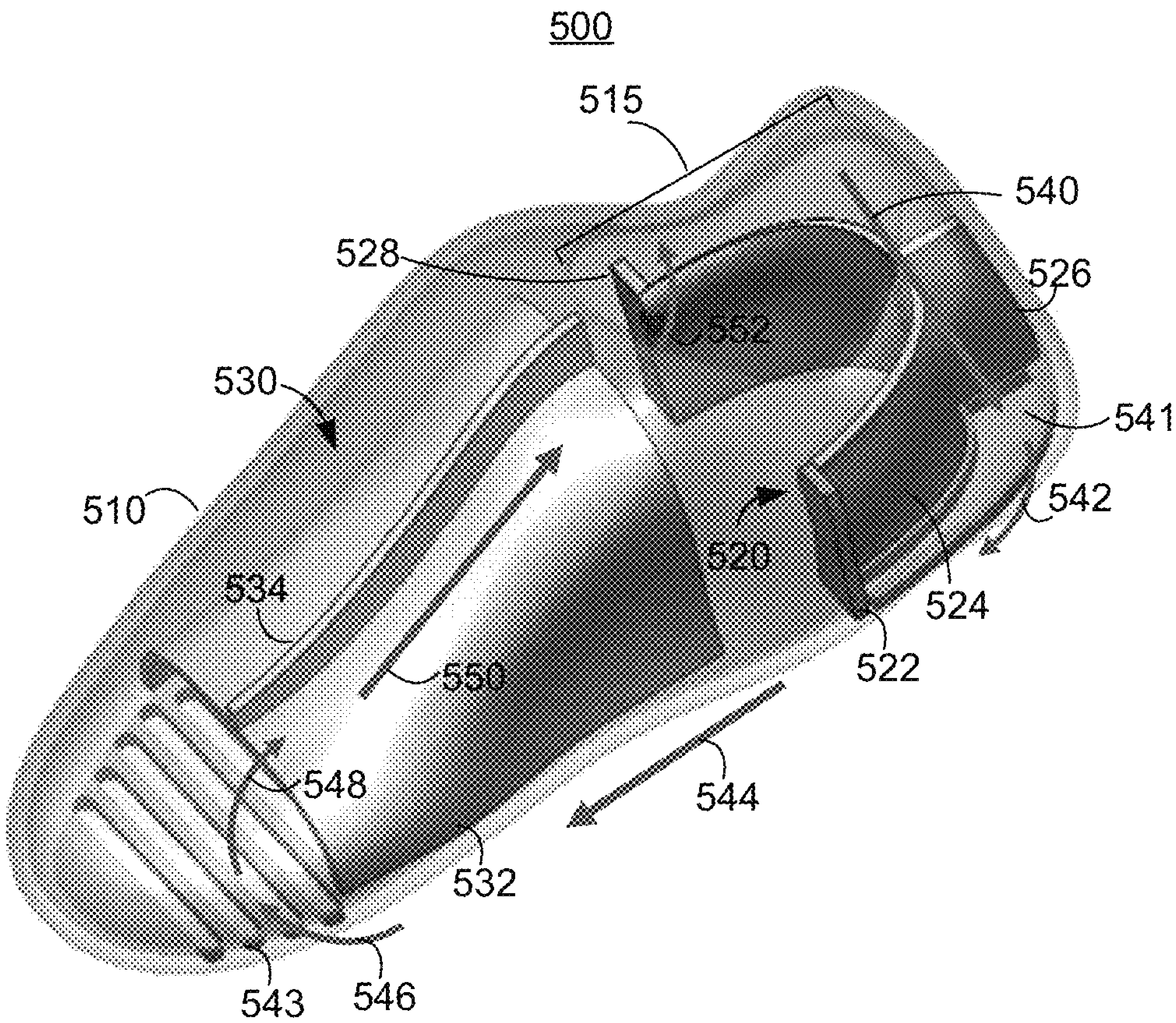
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FIG. 5A

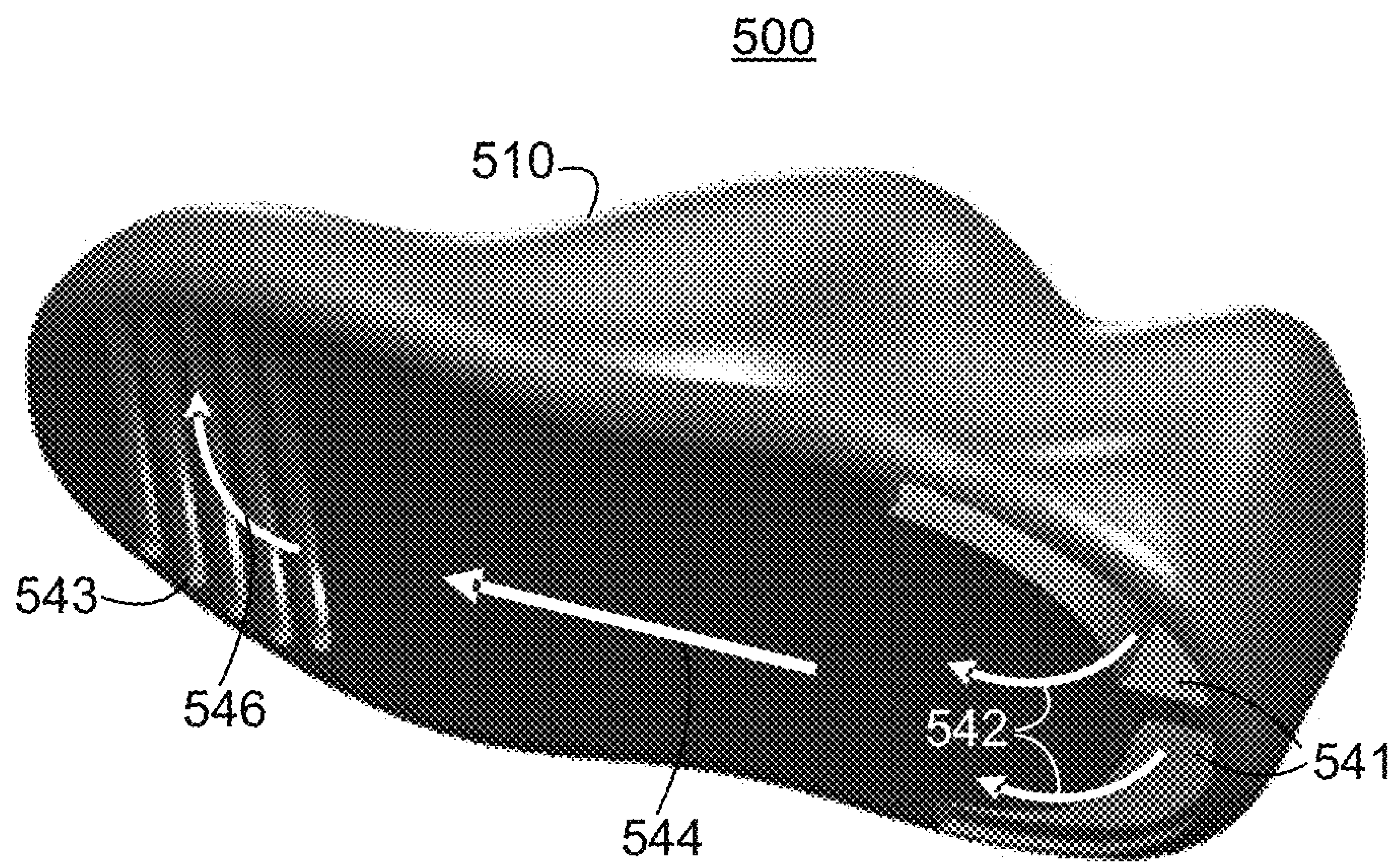
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FIG. 5B

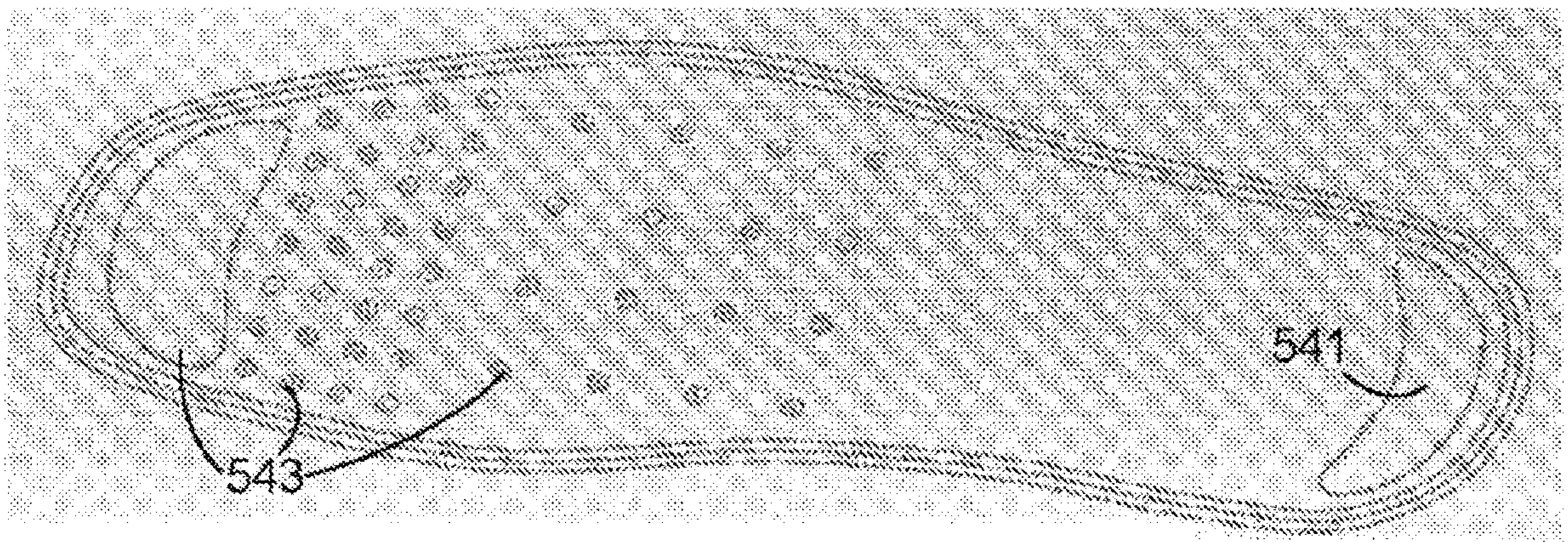

FIG. 5C

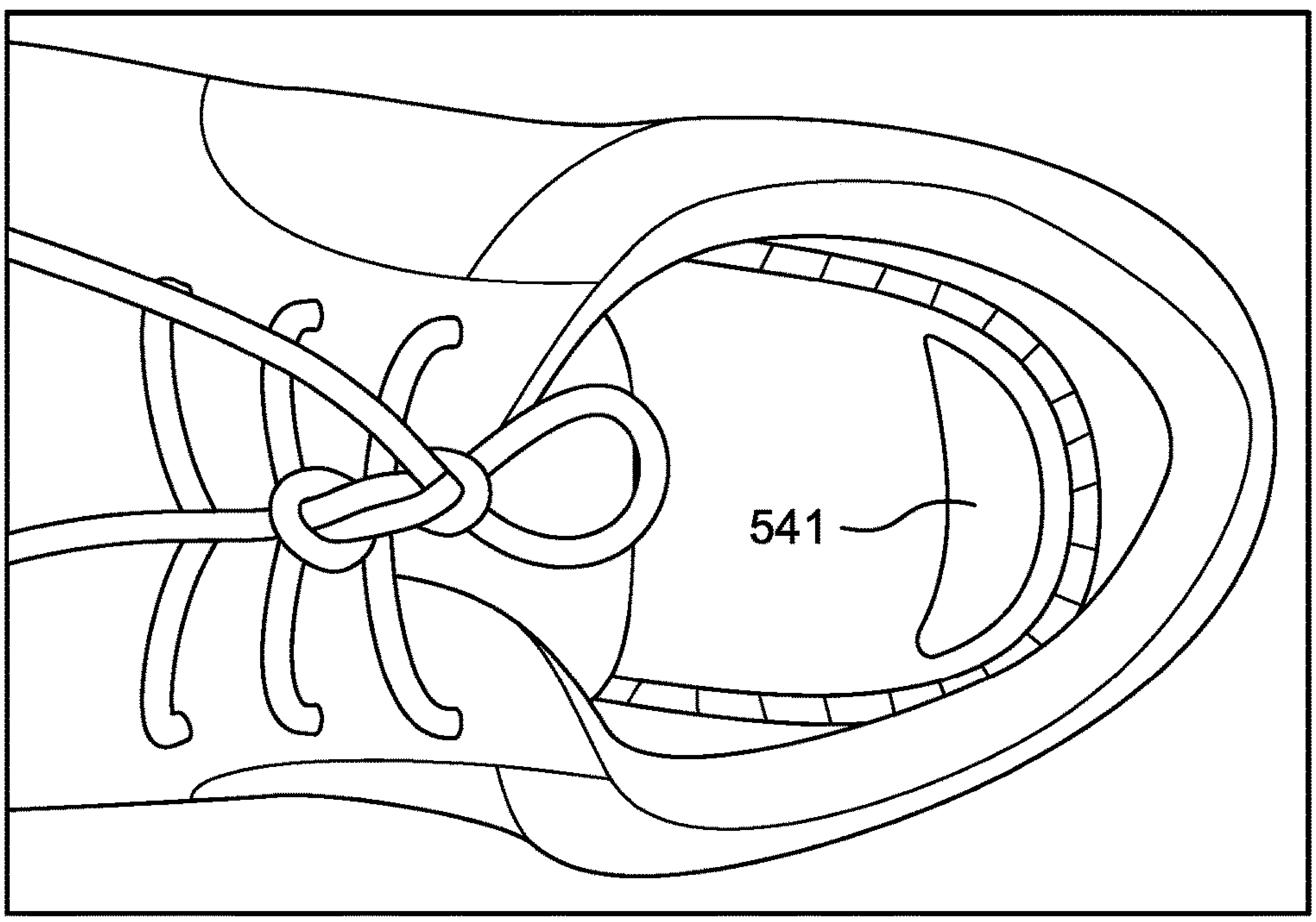

FIG. 5D

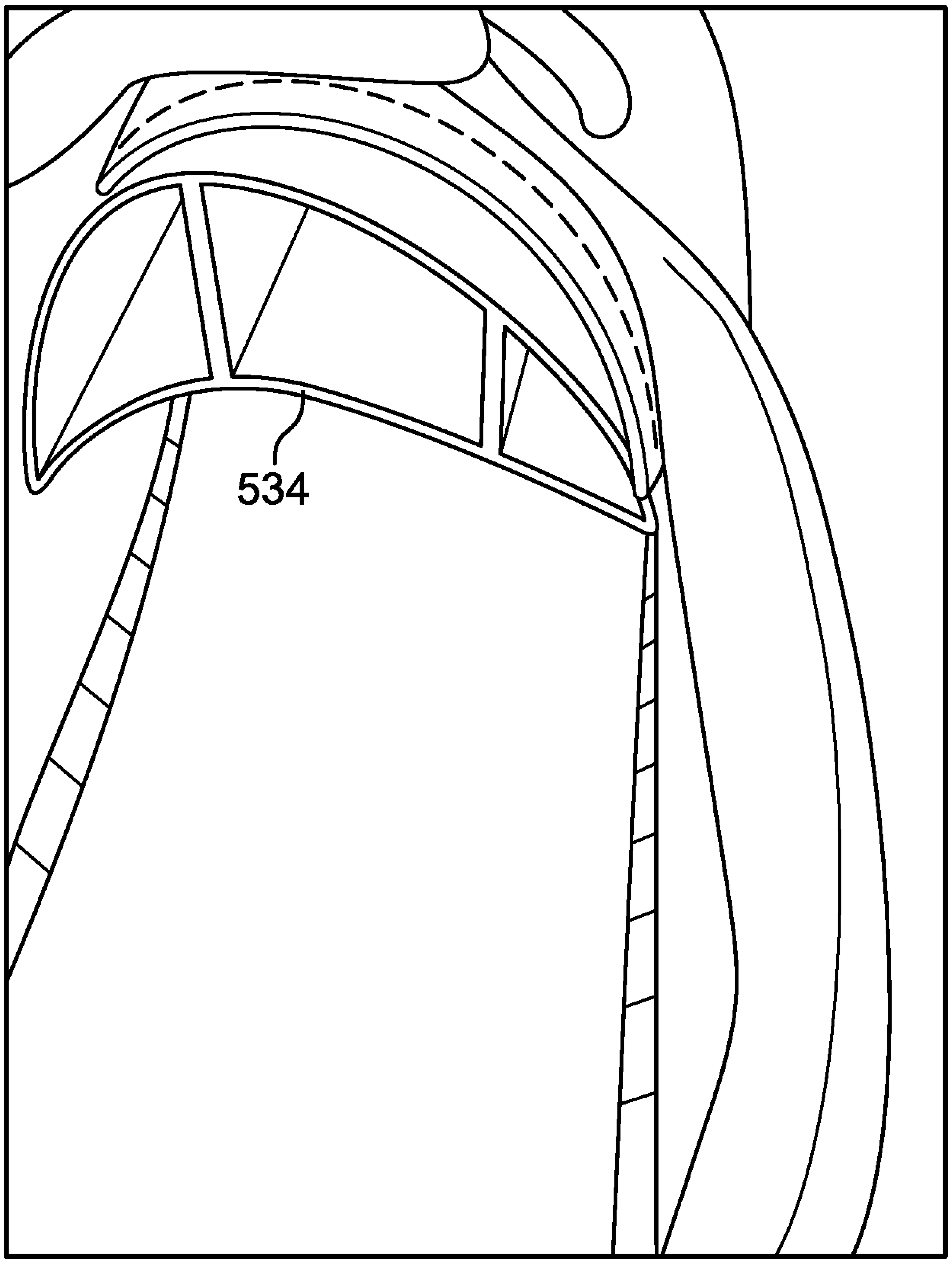

FIG. 5E

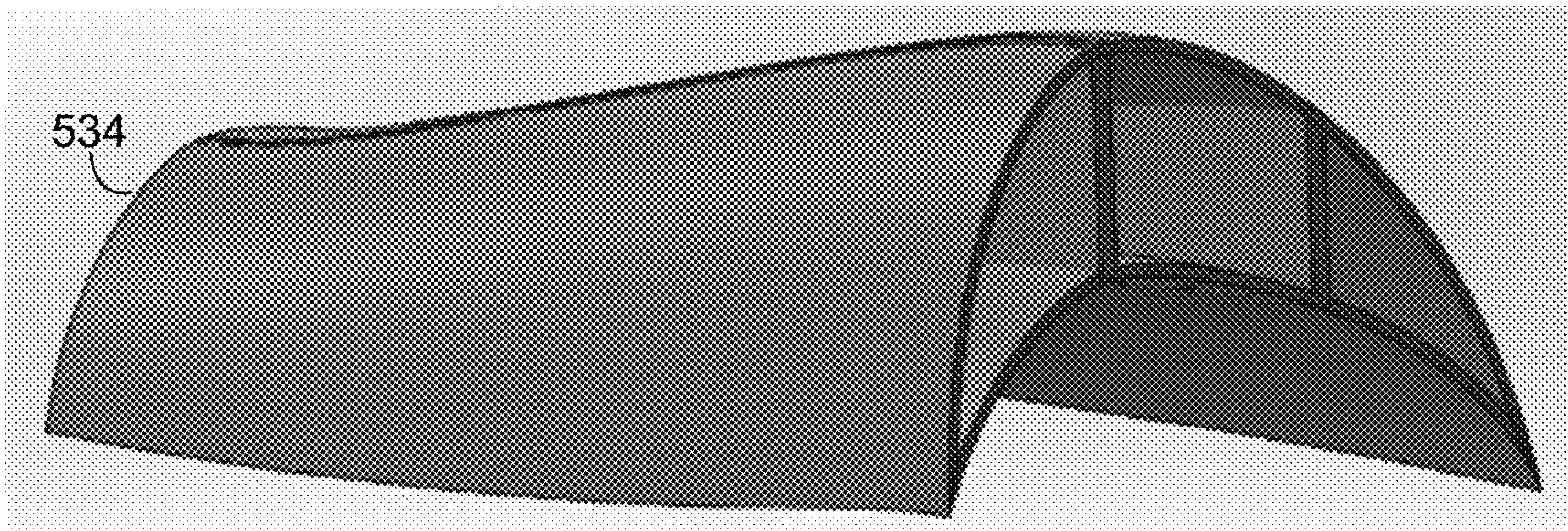

FIG. 5F

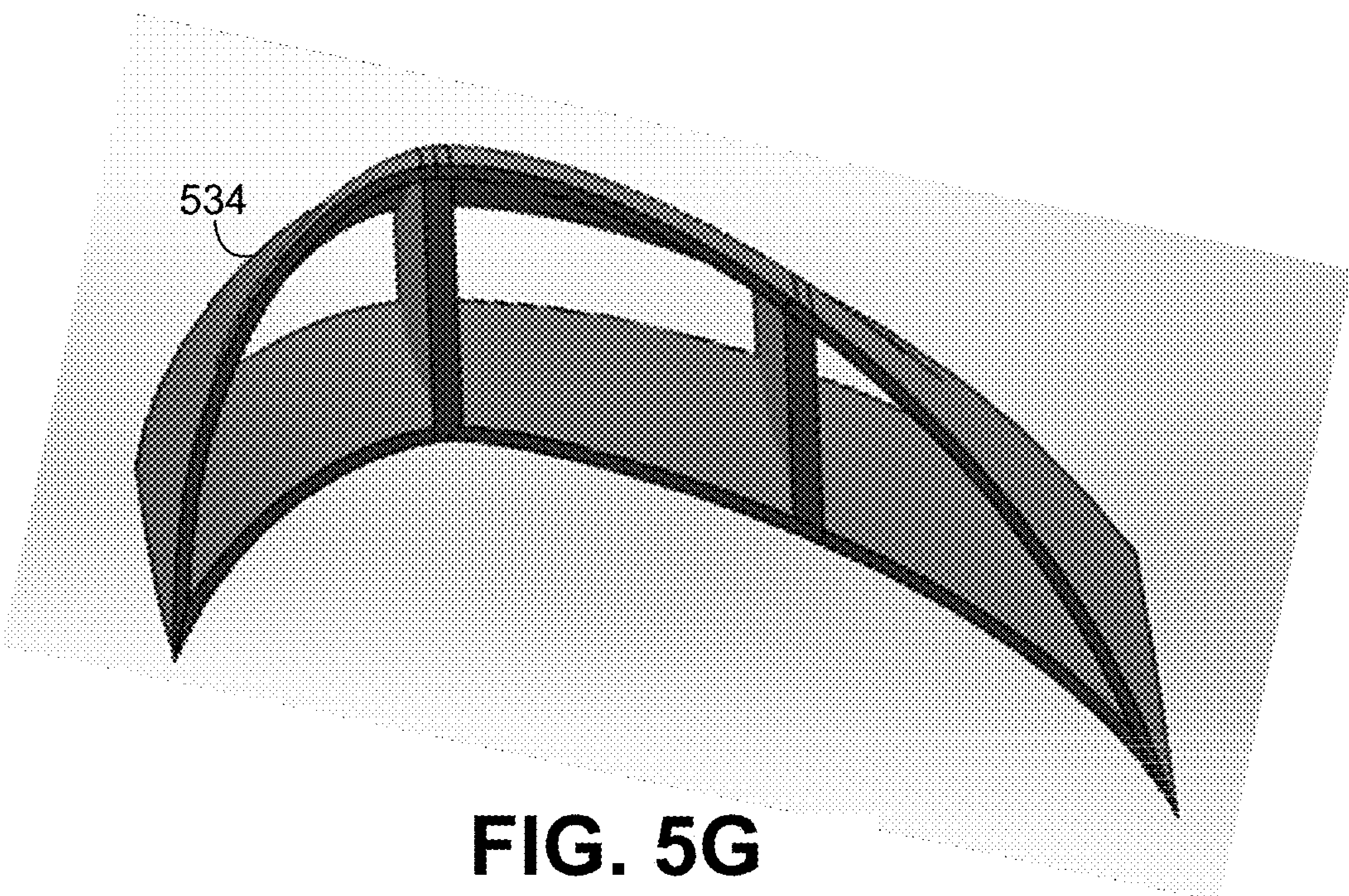

FIG. 5G

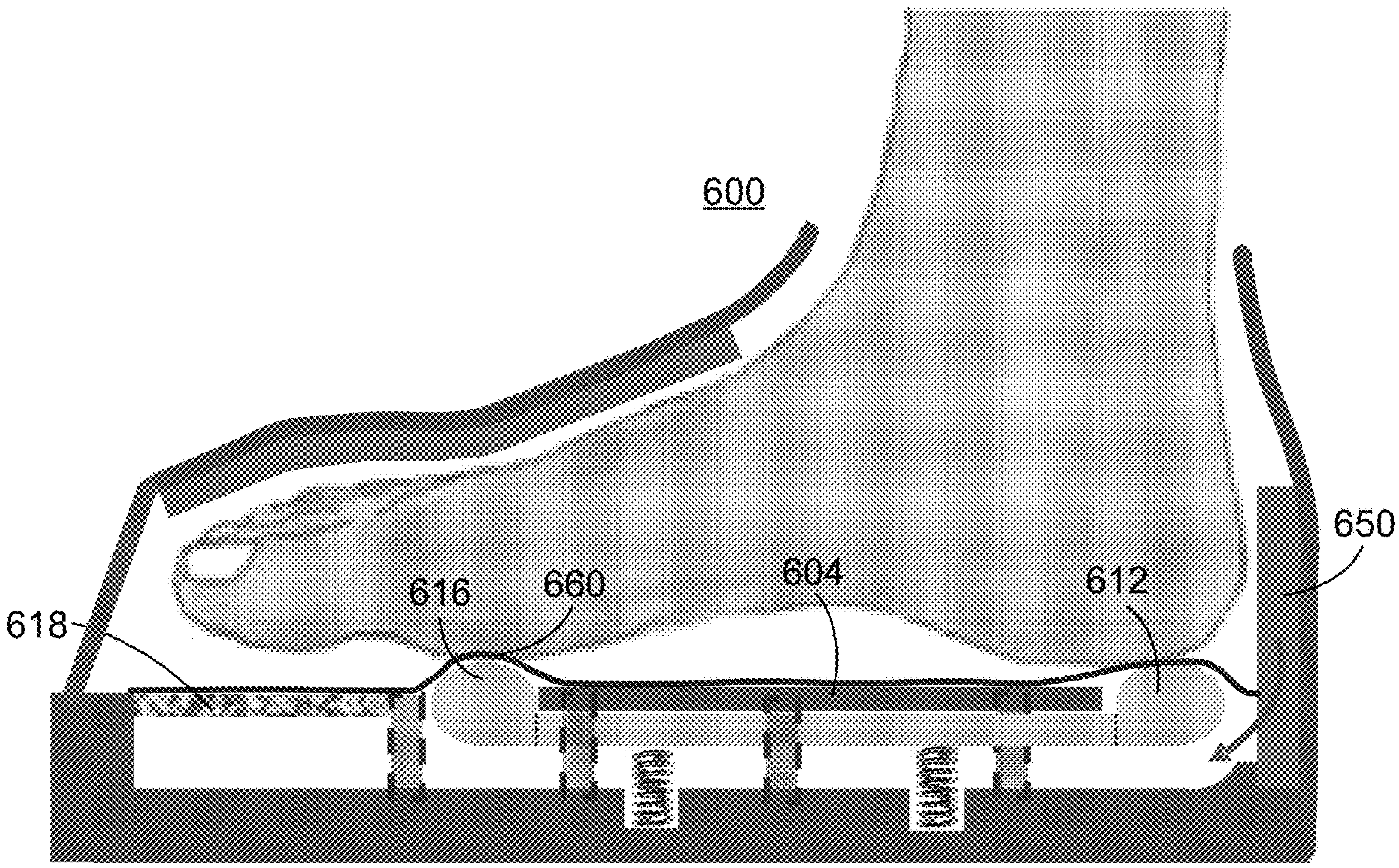

FIG. 6

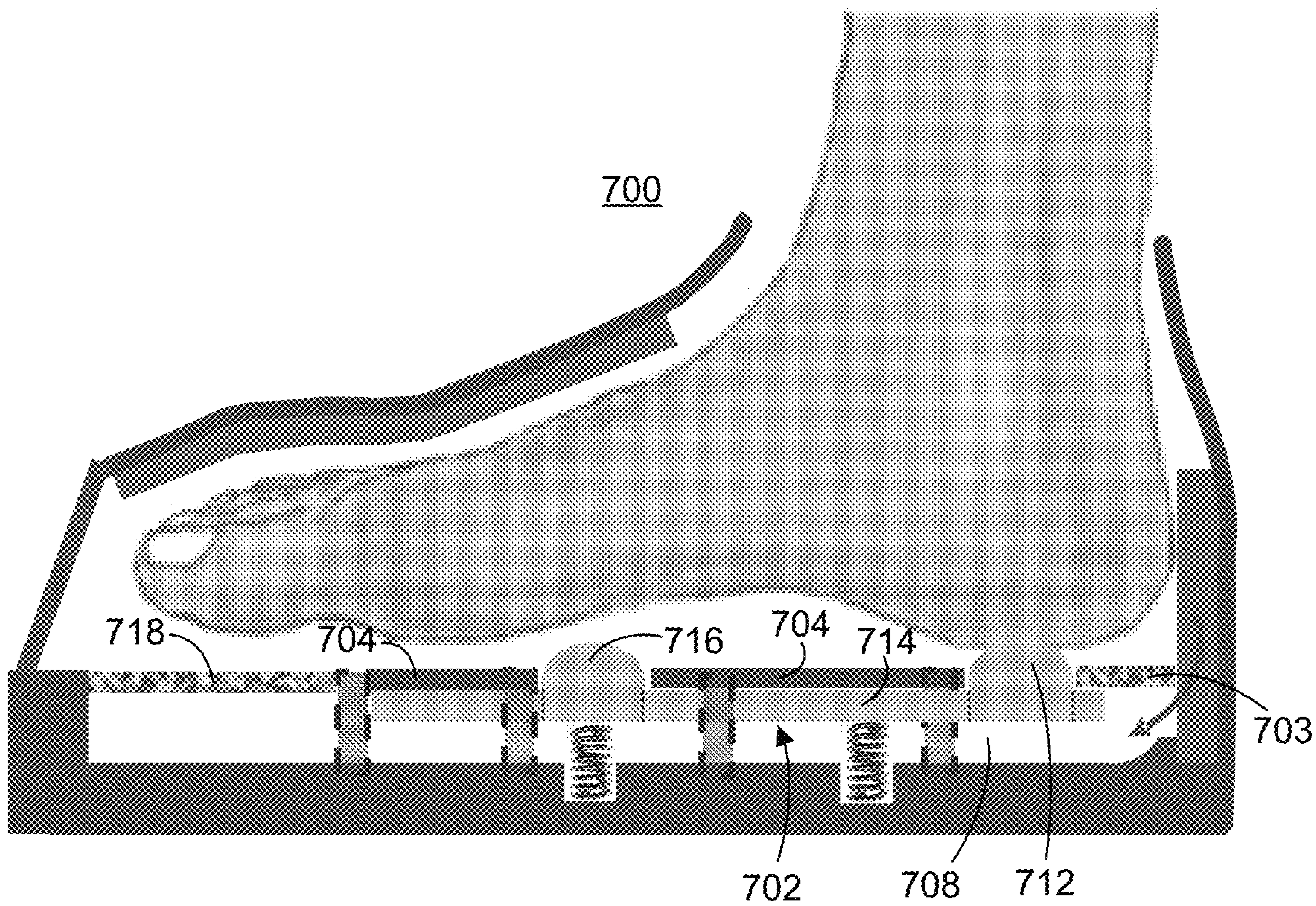

FIG. 7

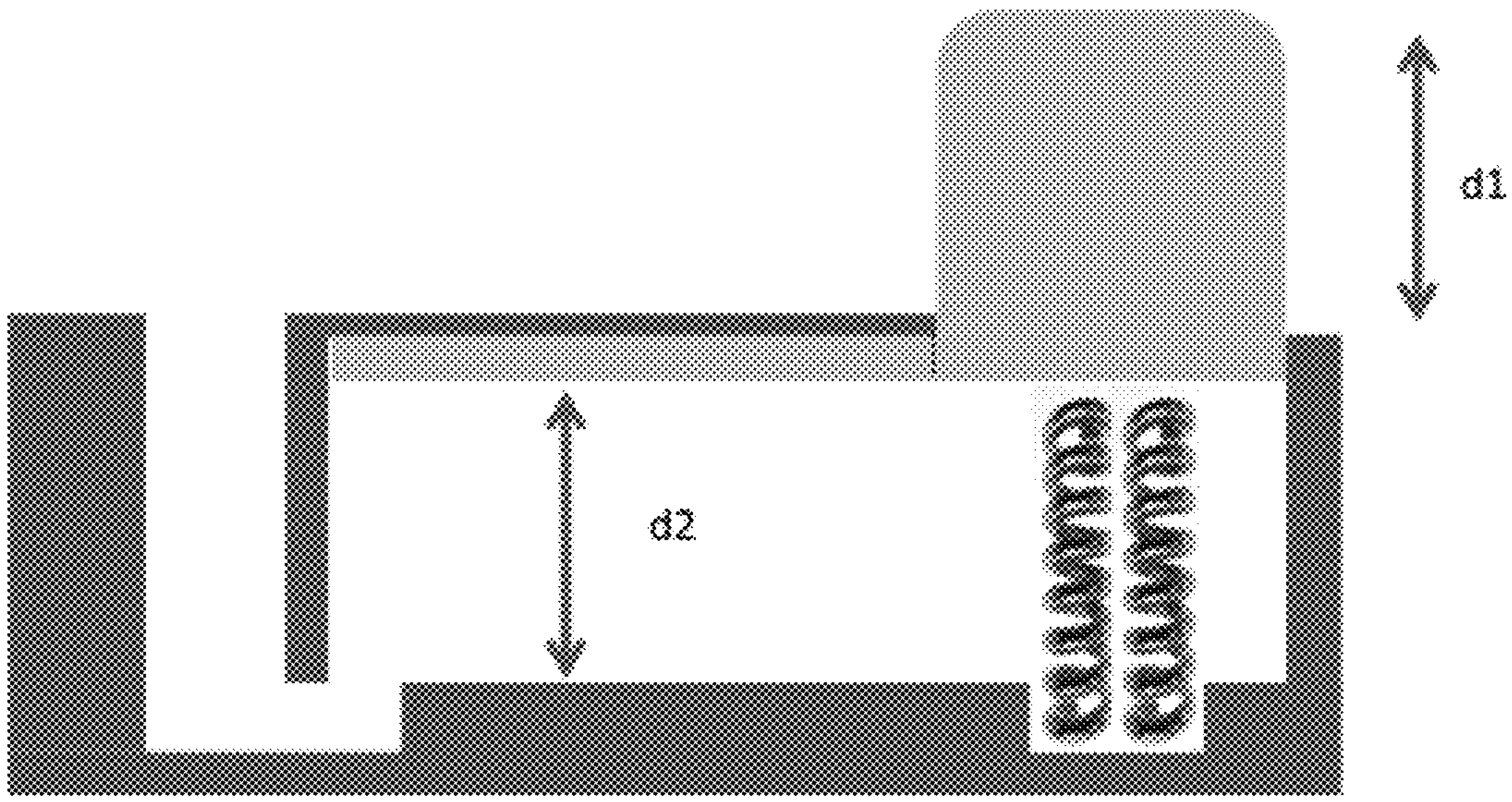

FIG. 8A

FIG. 8B

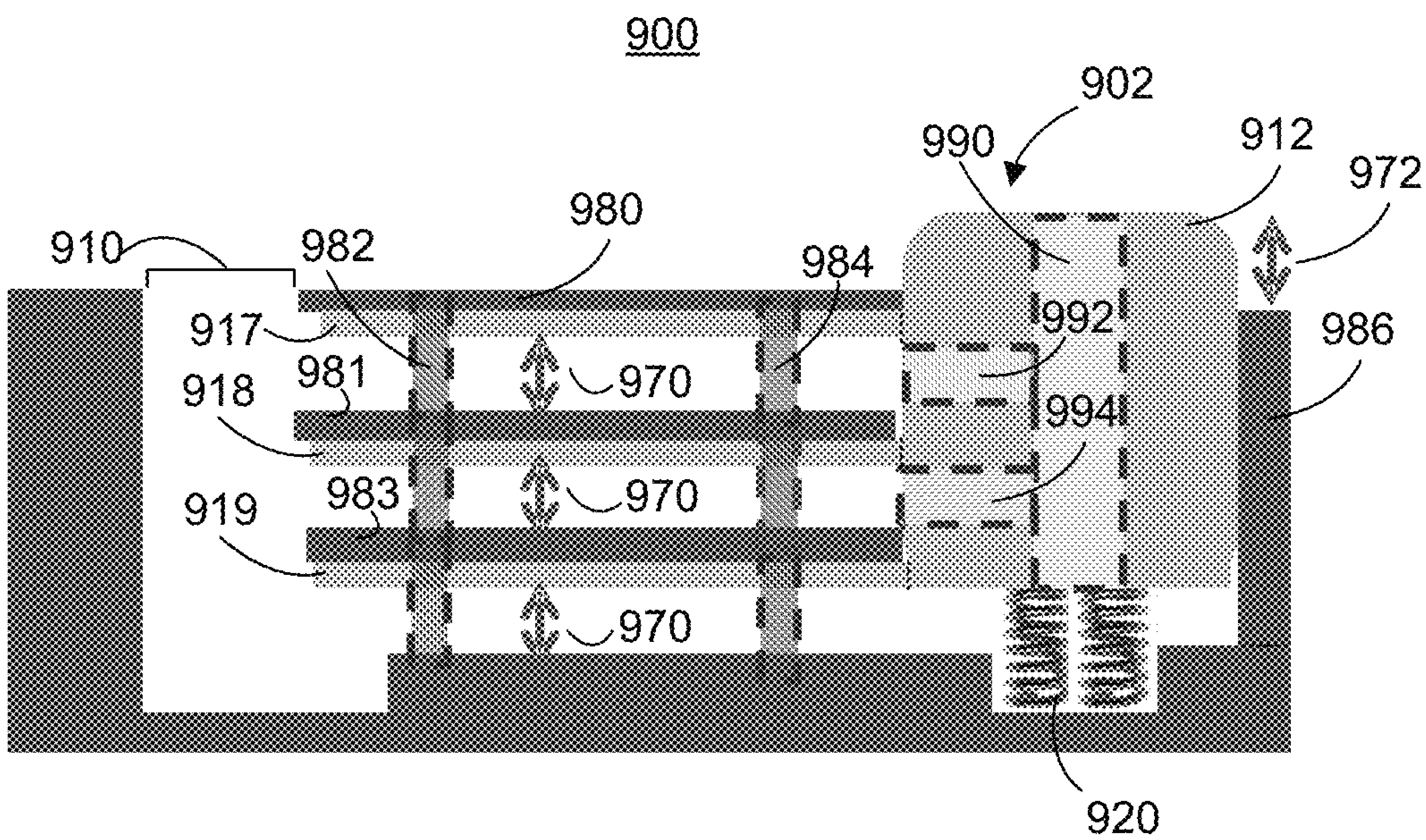
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FIG. 9A

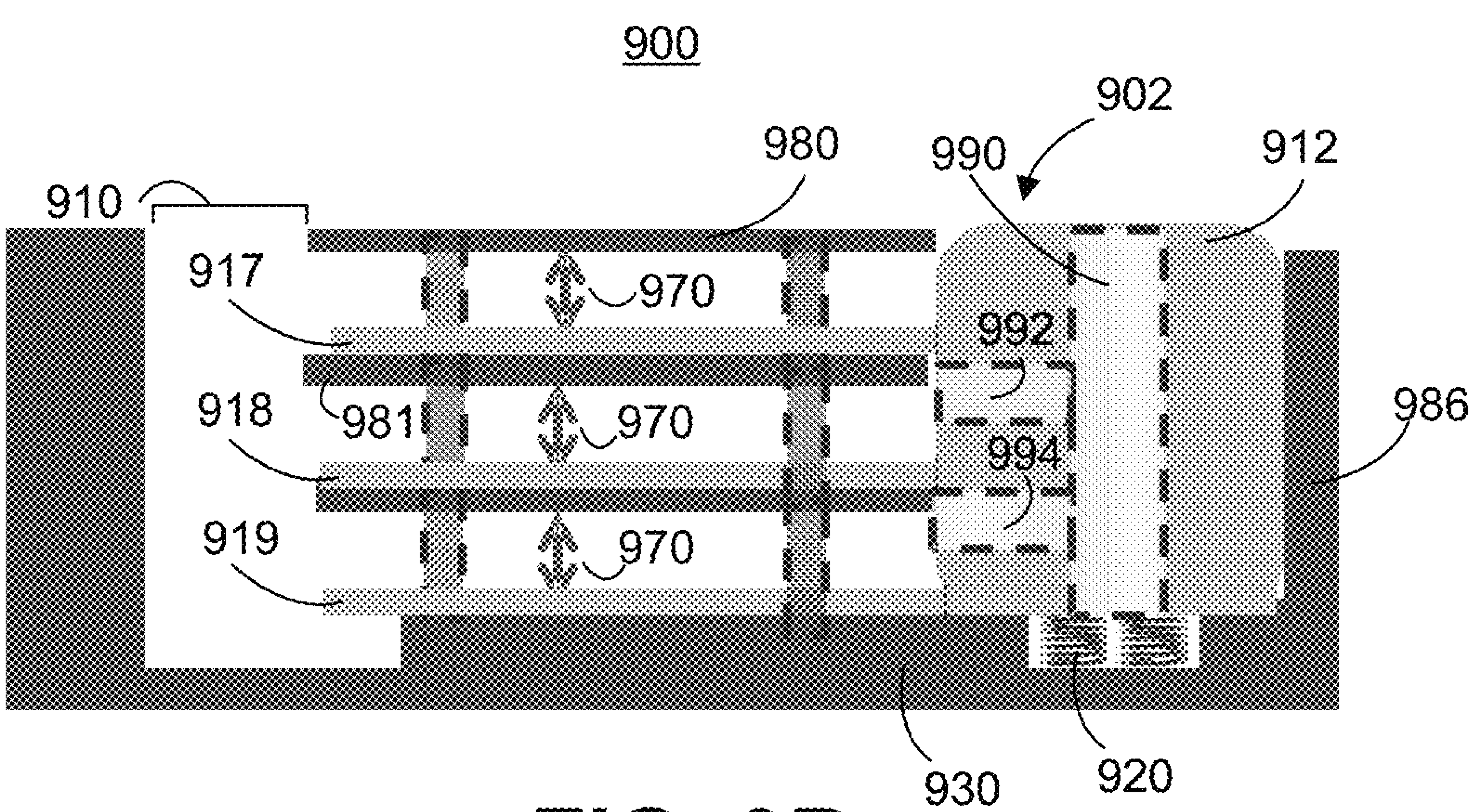
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FIG. 9B

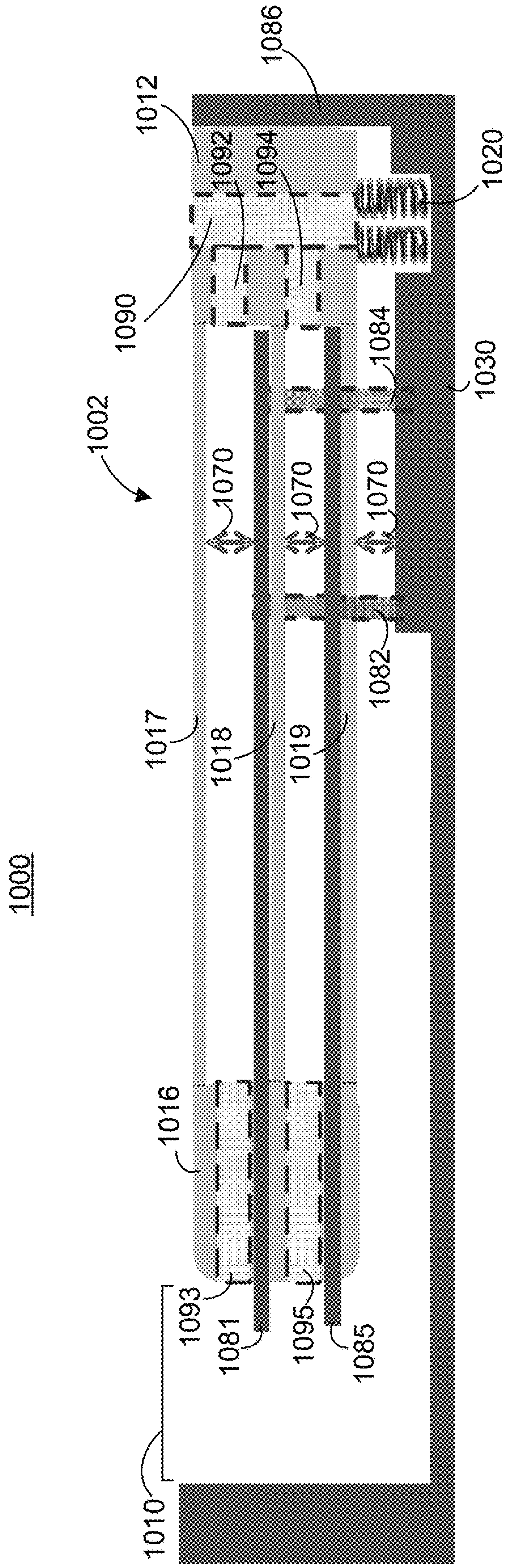
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FIG. 10

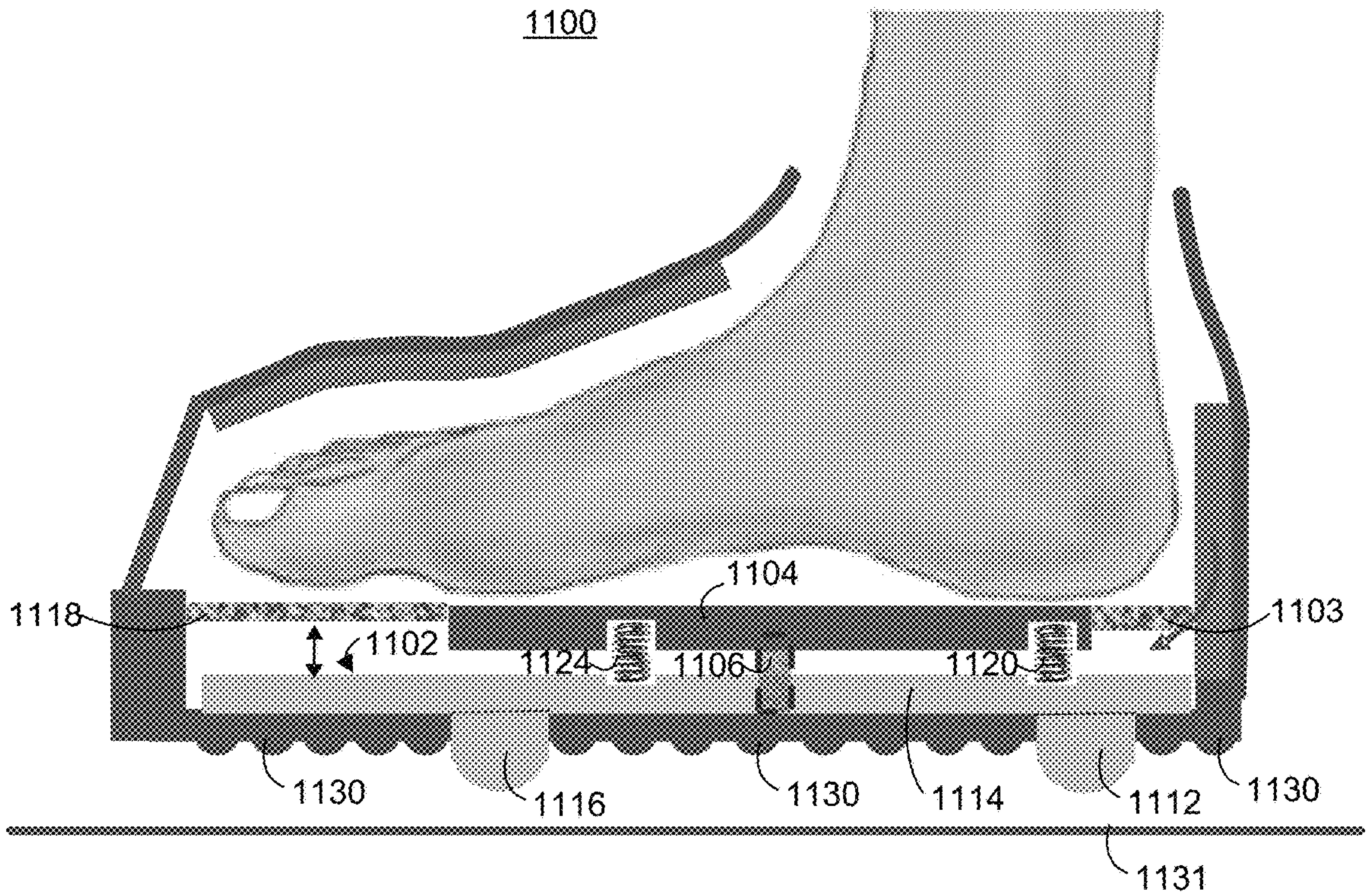

FIG. 11A

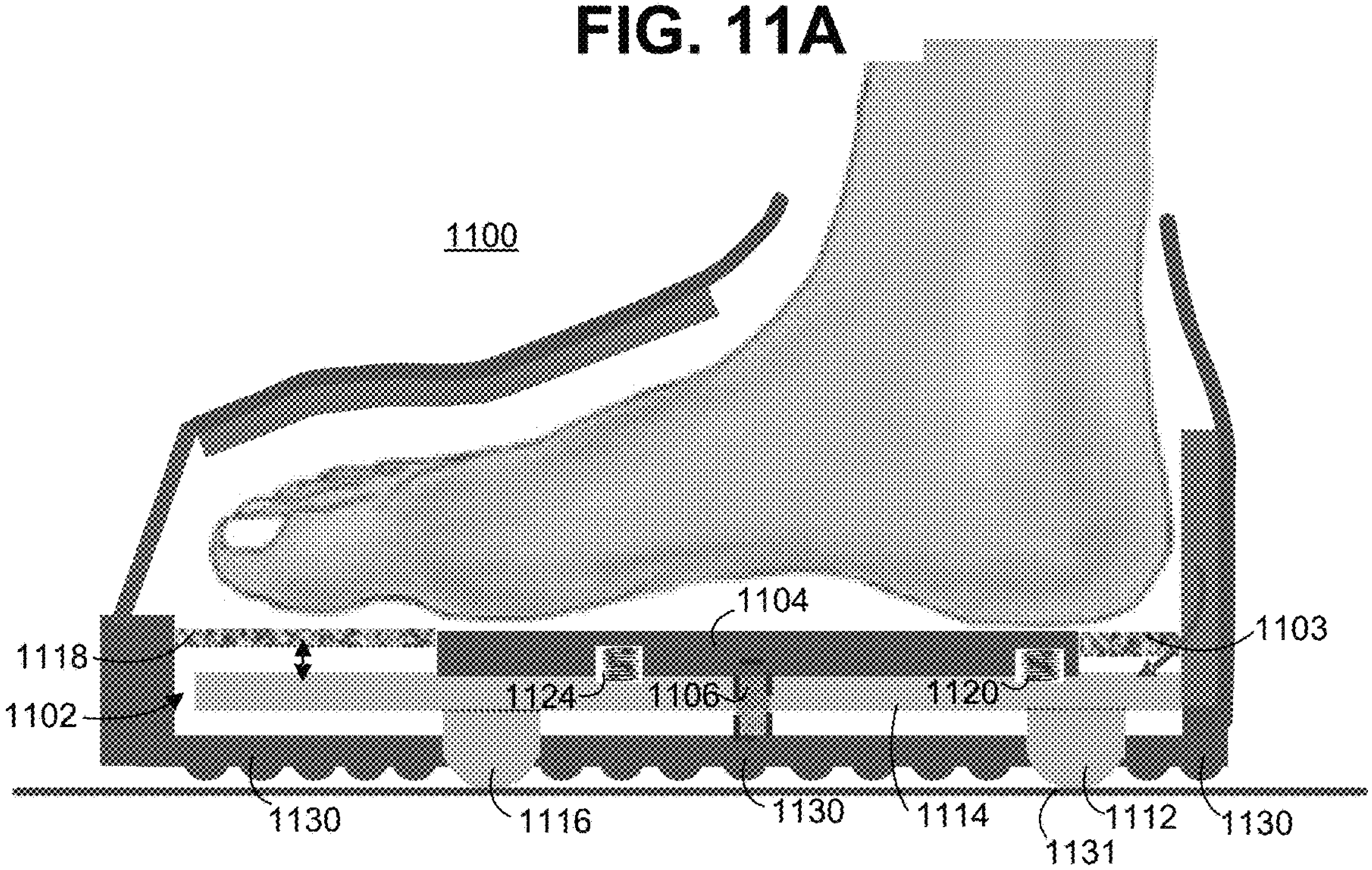

FIG. 11B

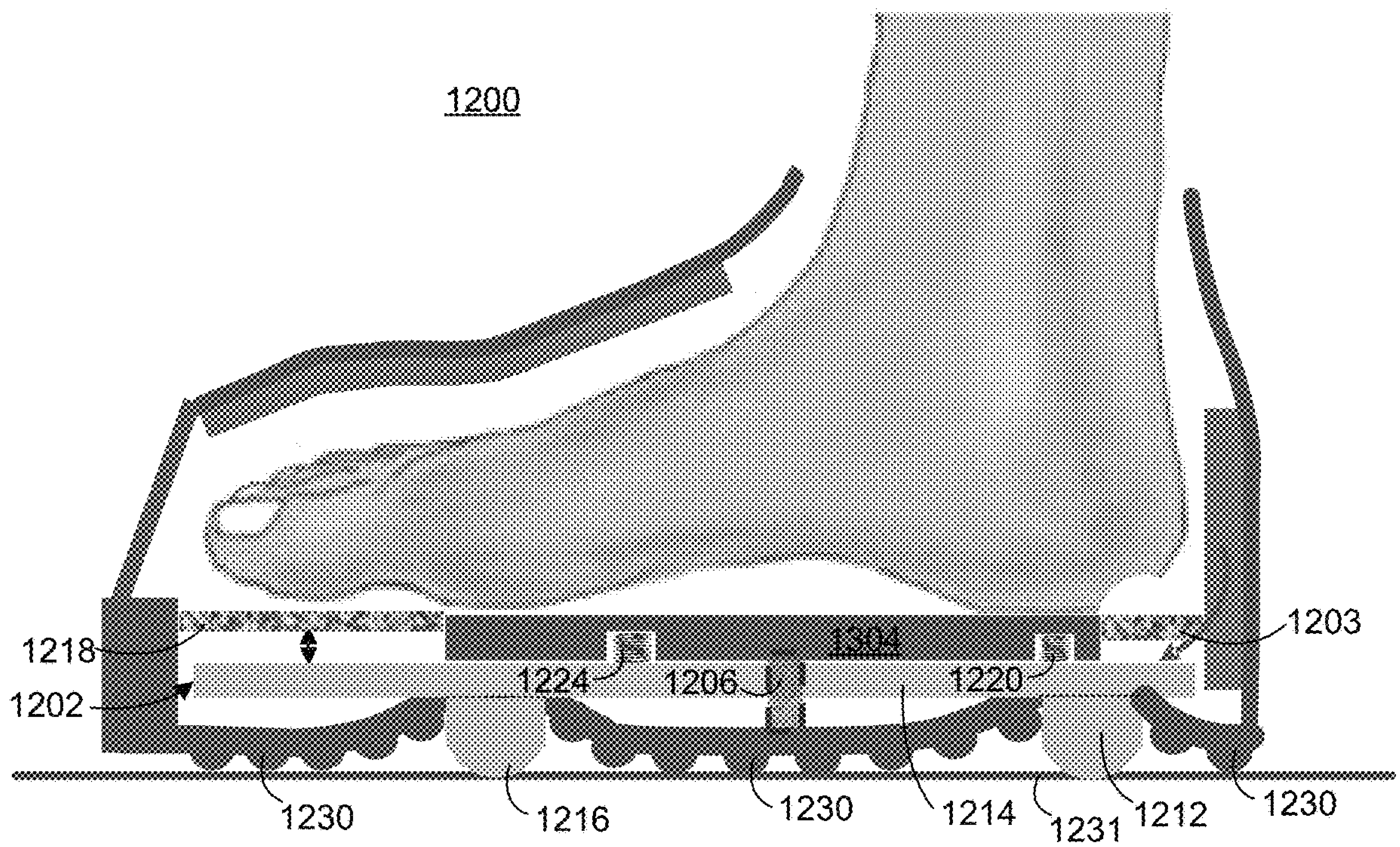
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FIG. 12

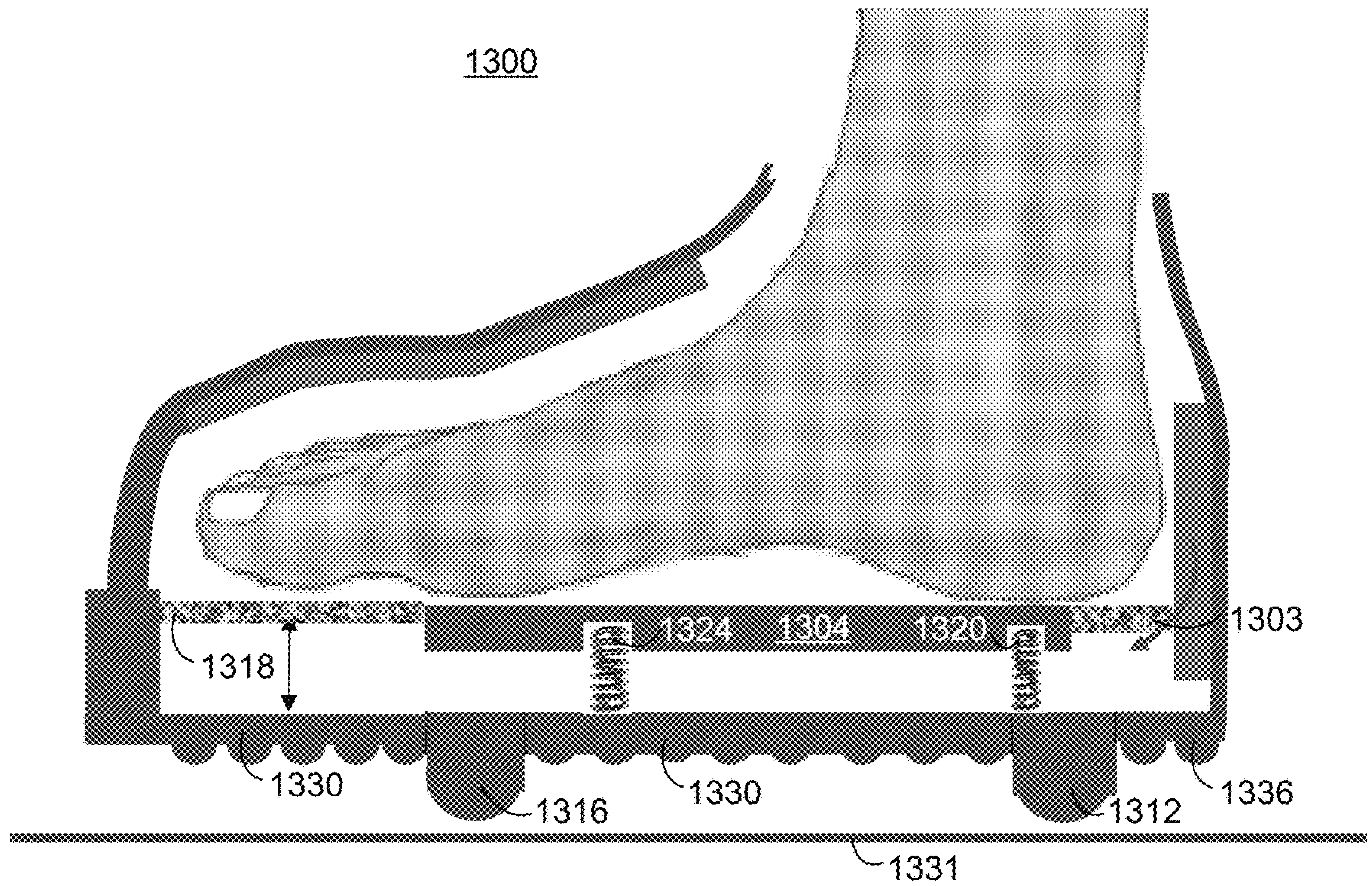

FIG. 13A

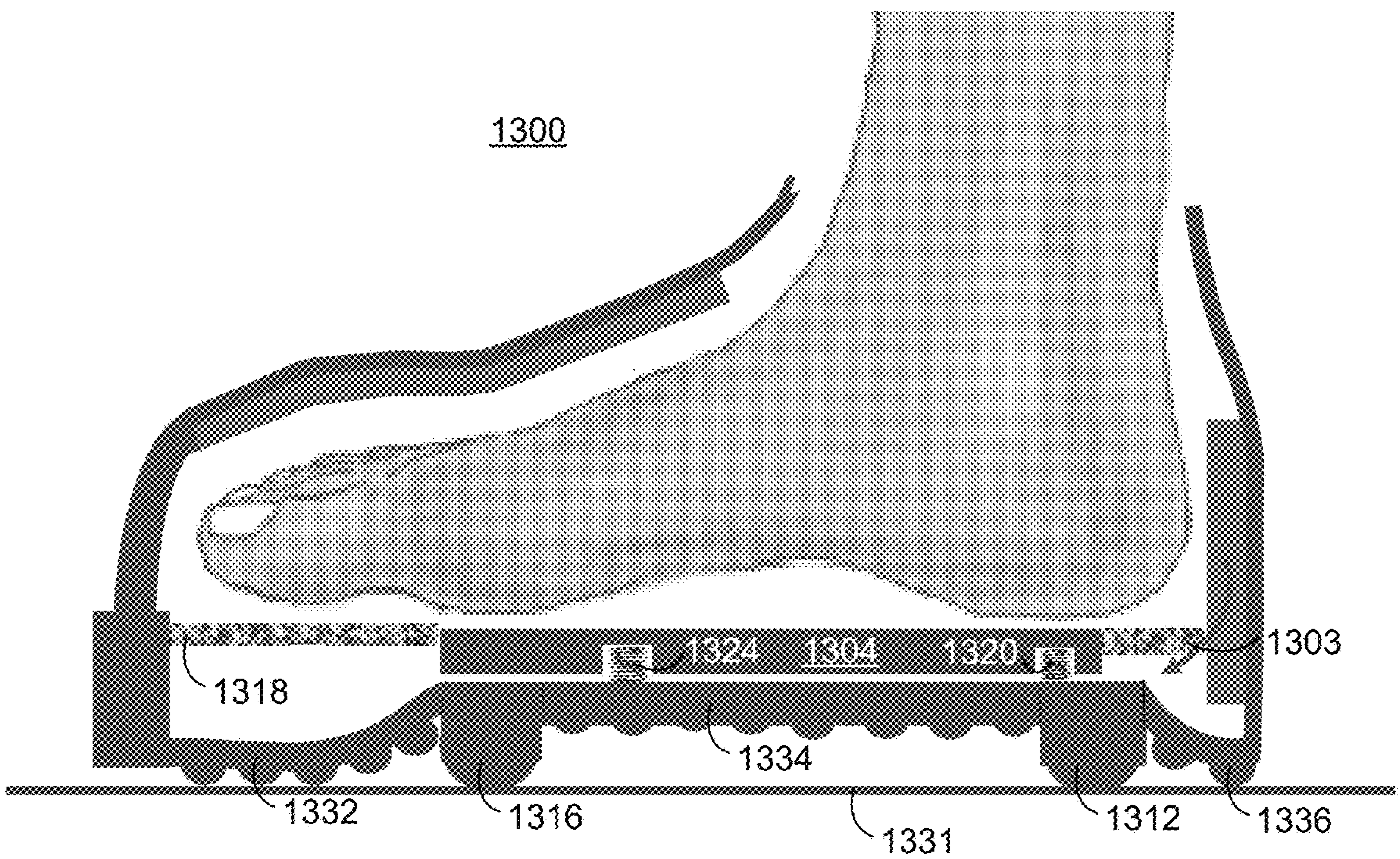

FIG. 13B

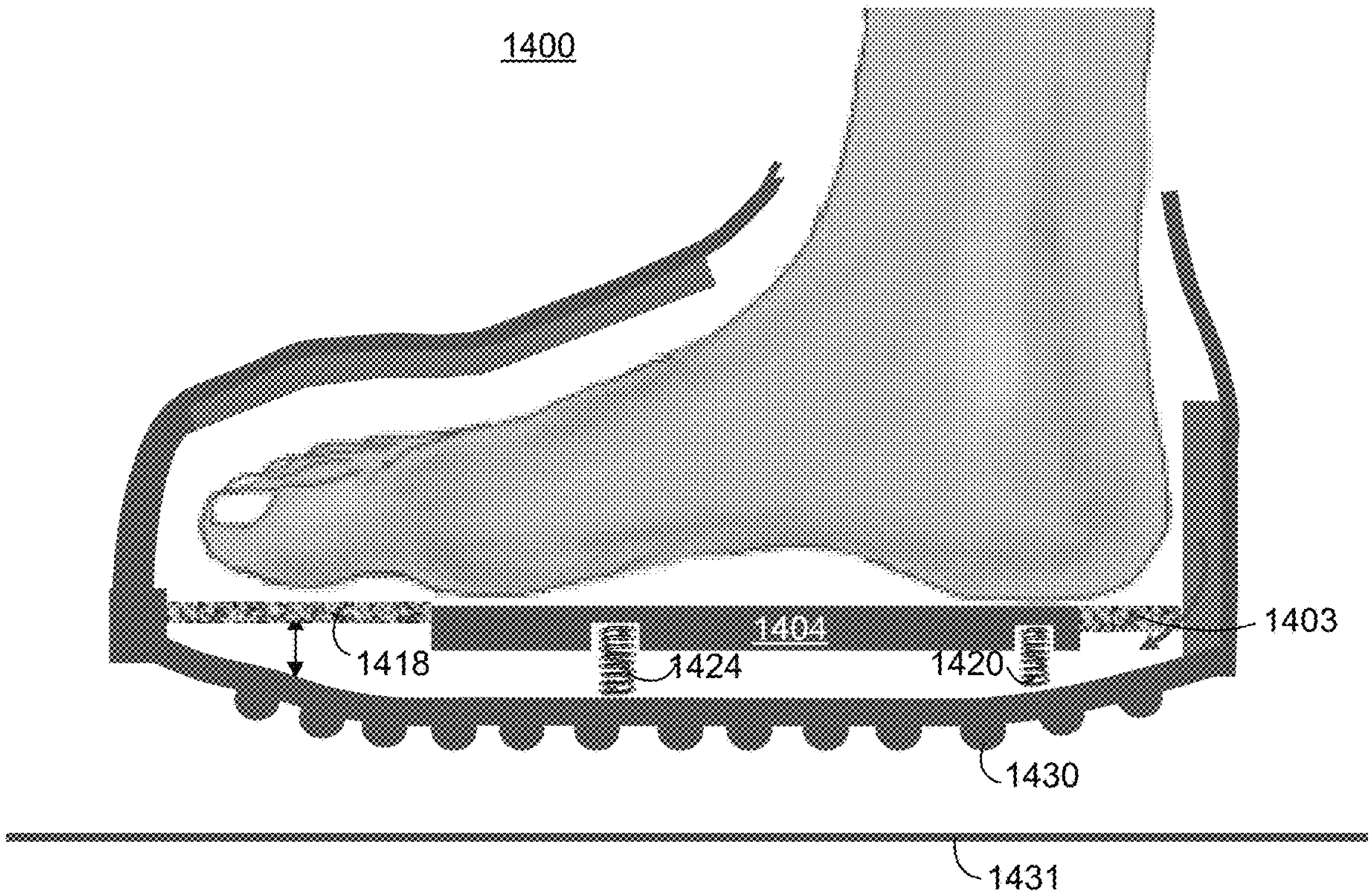

FIG. 14A

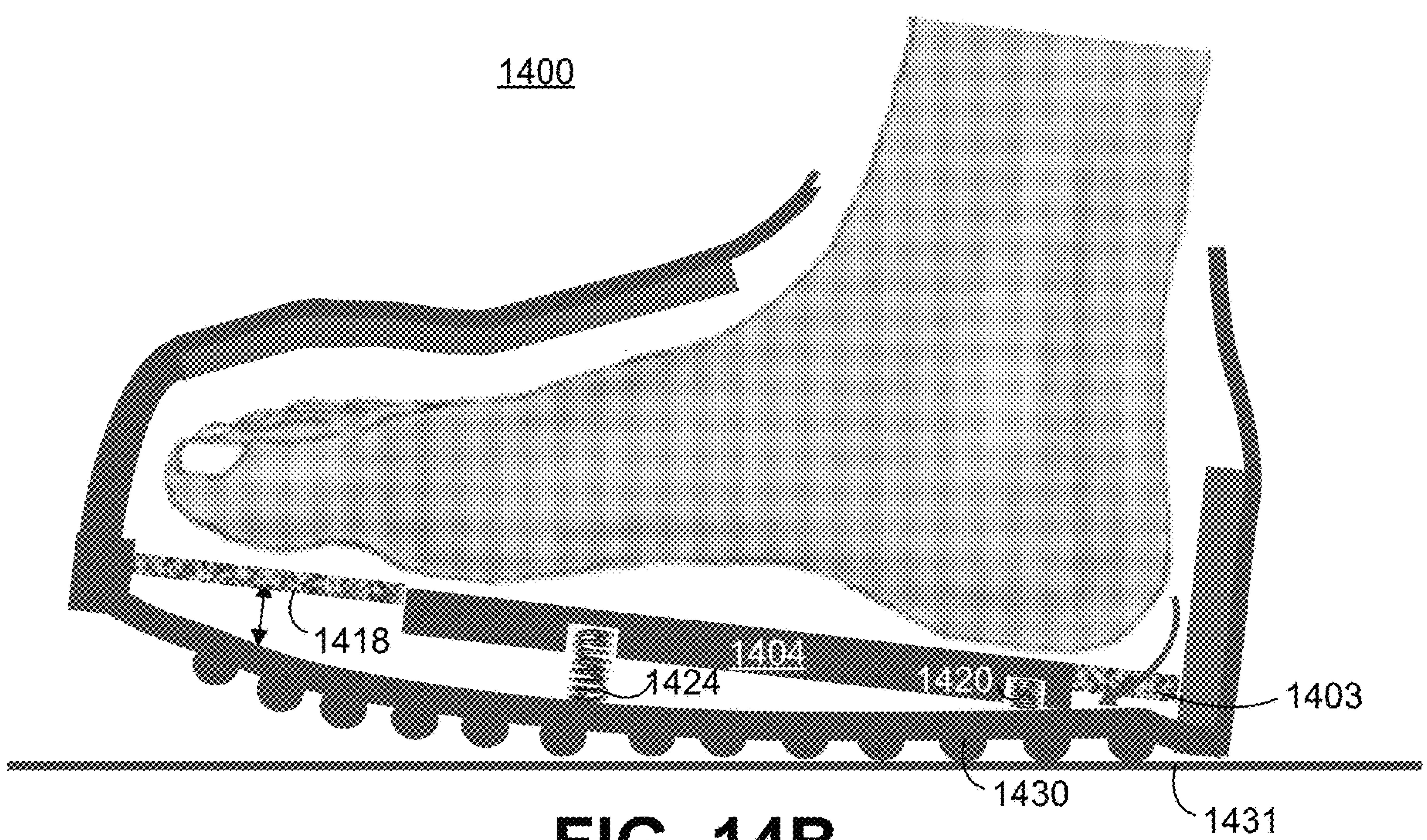

FIG. 14B

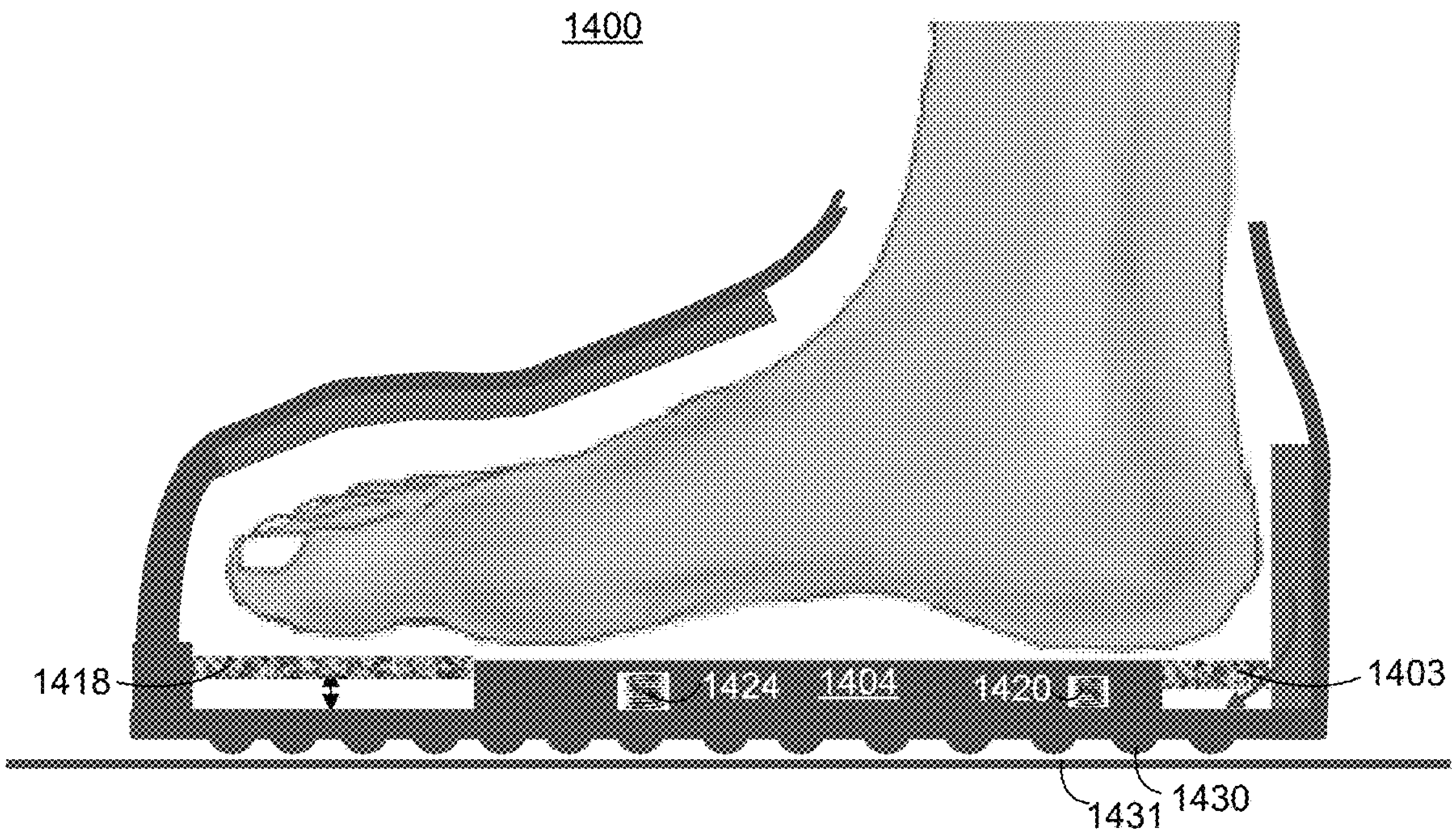

FIG. 14C

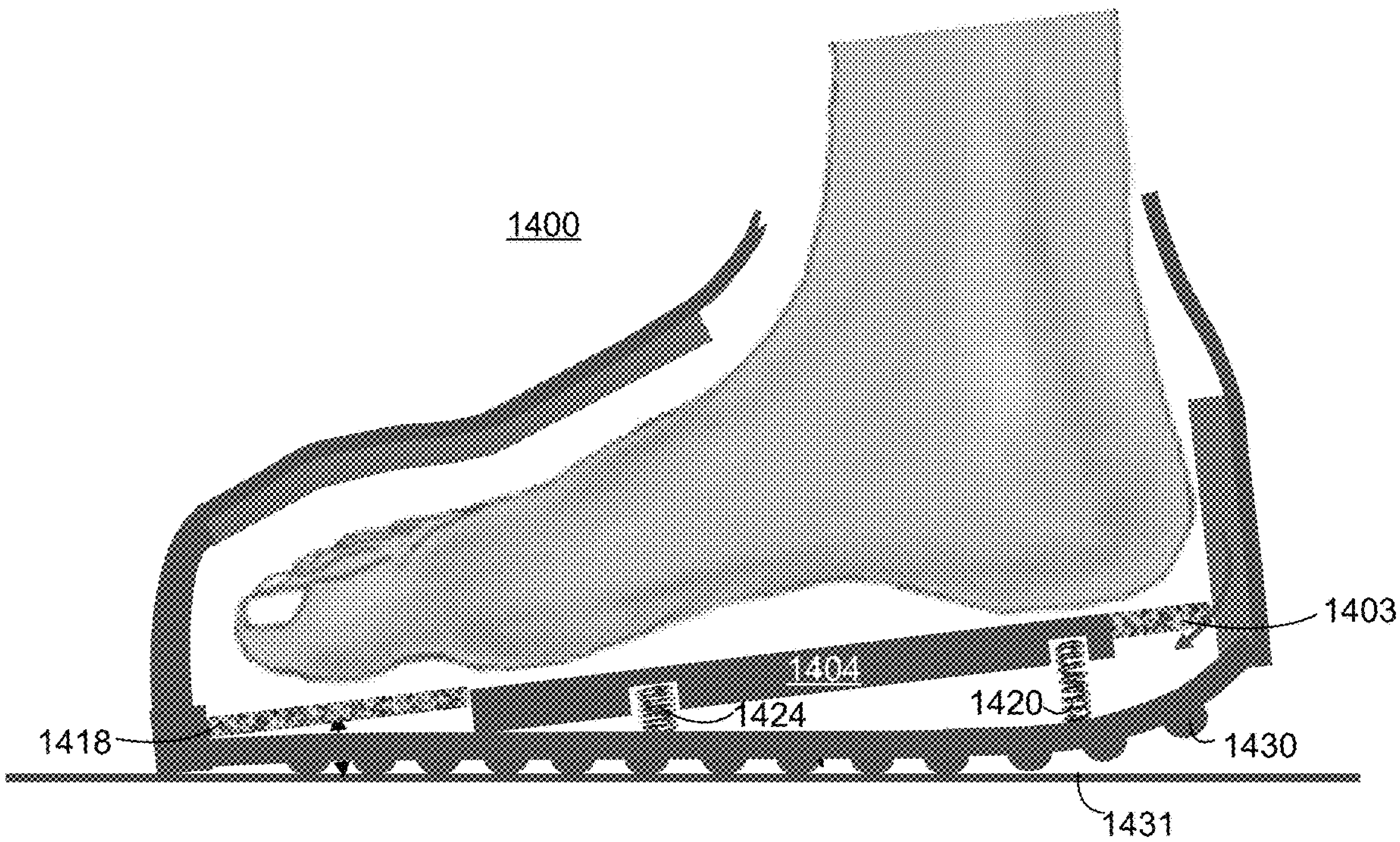

FIG. 14D

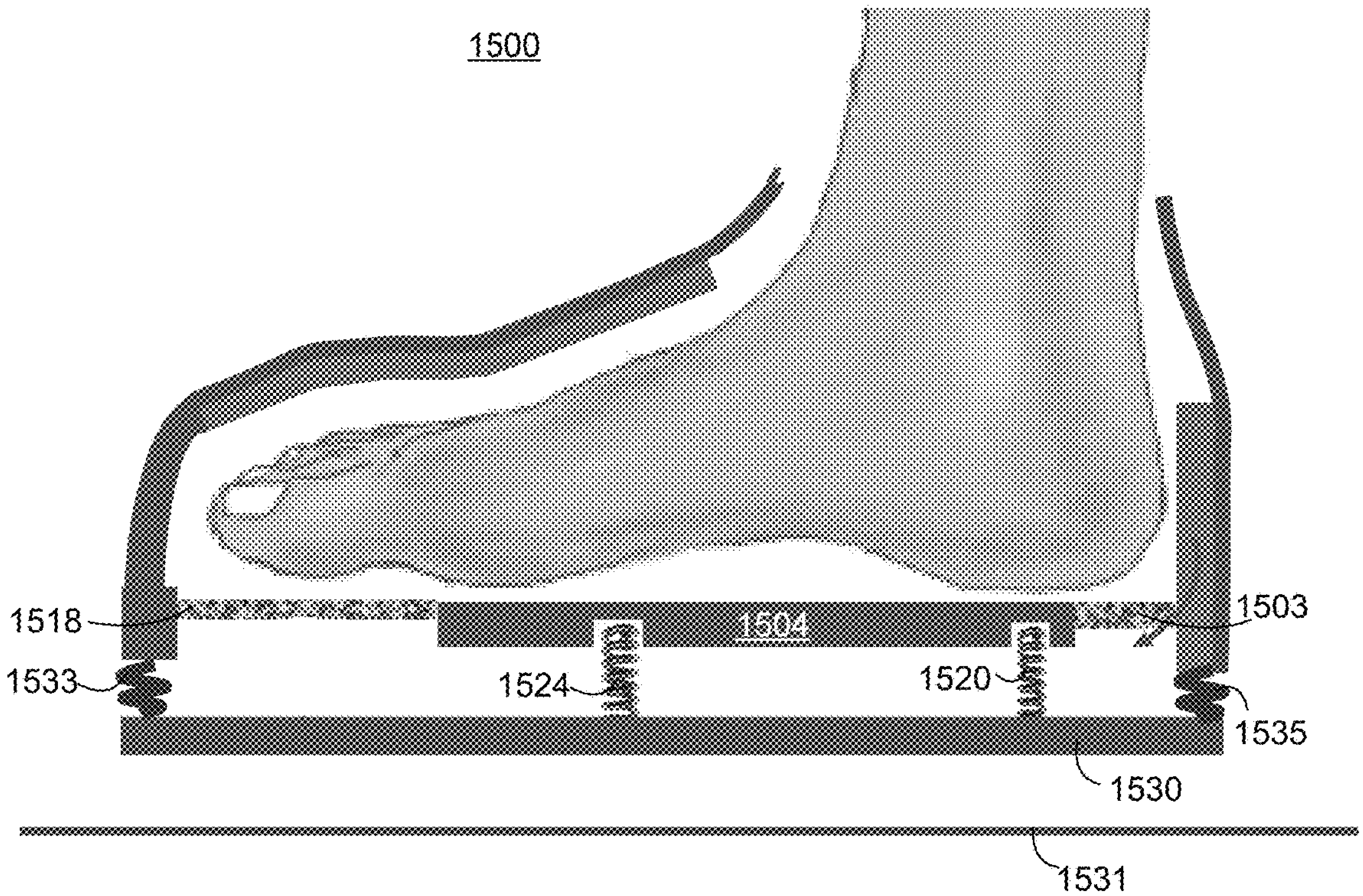

FIG. 15A

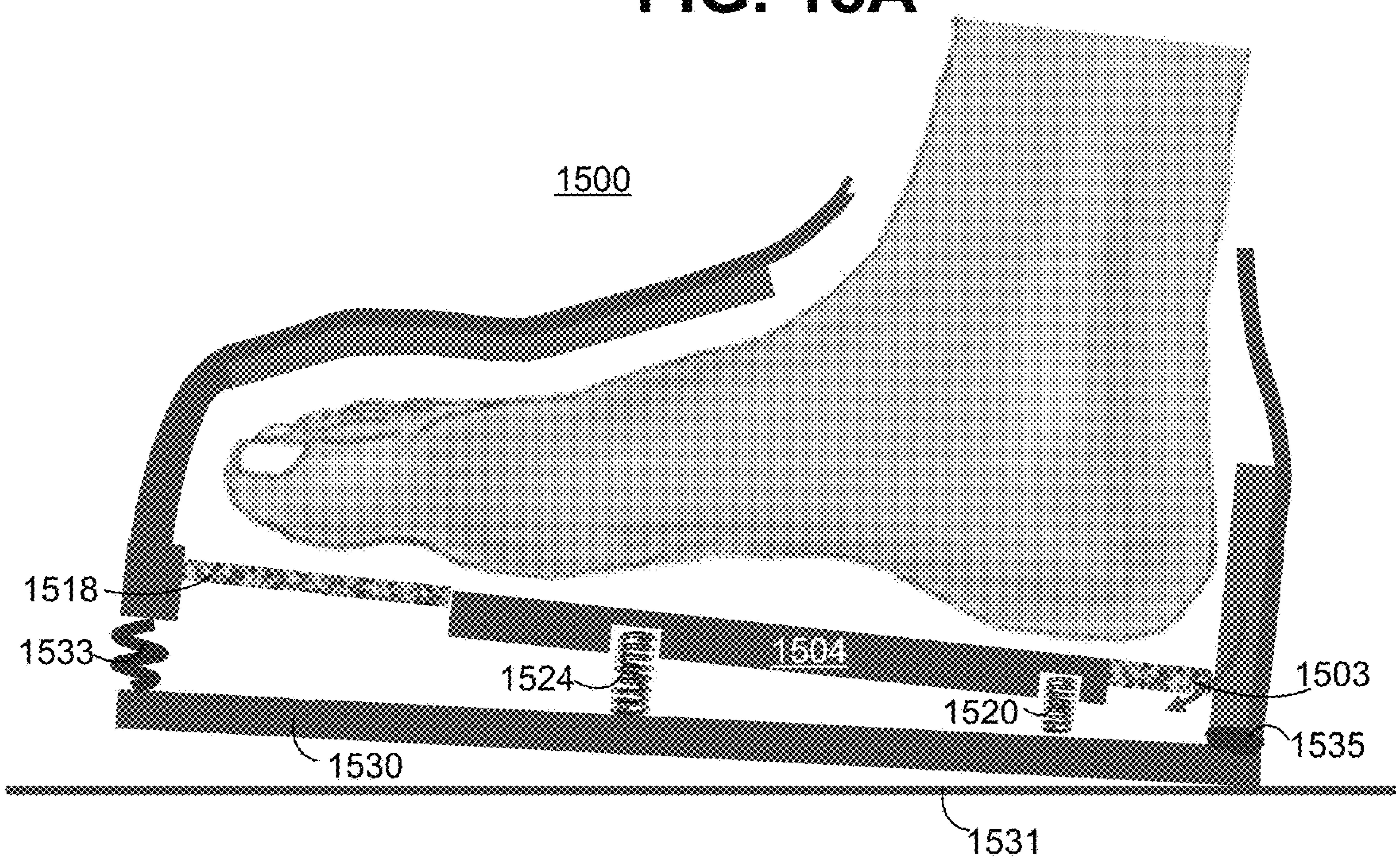

FIG. 15B

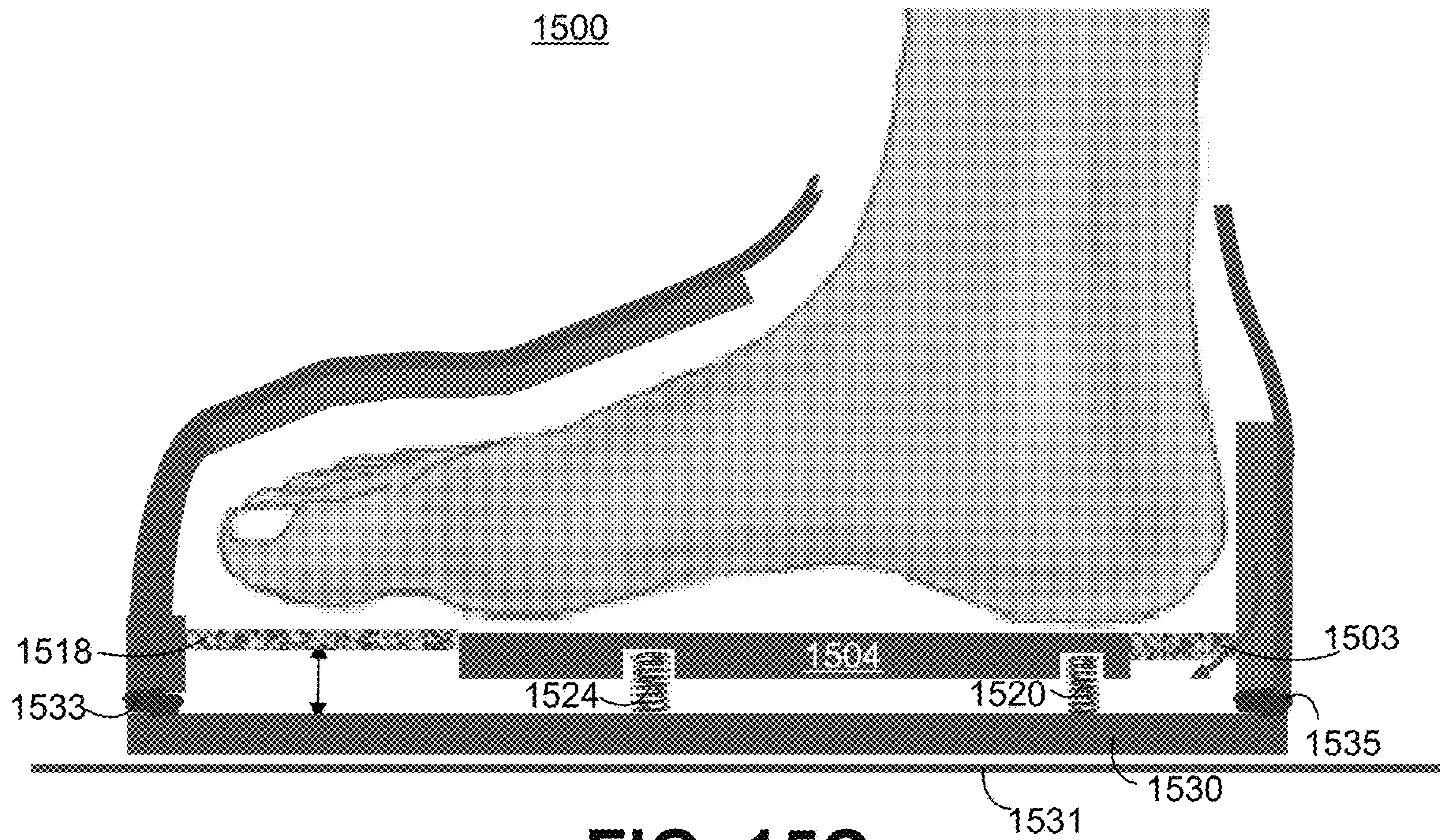

FIG. 15C

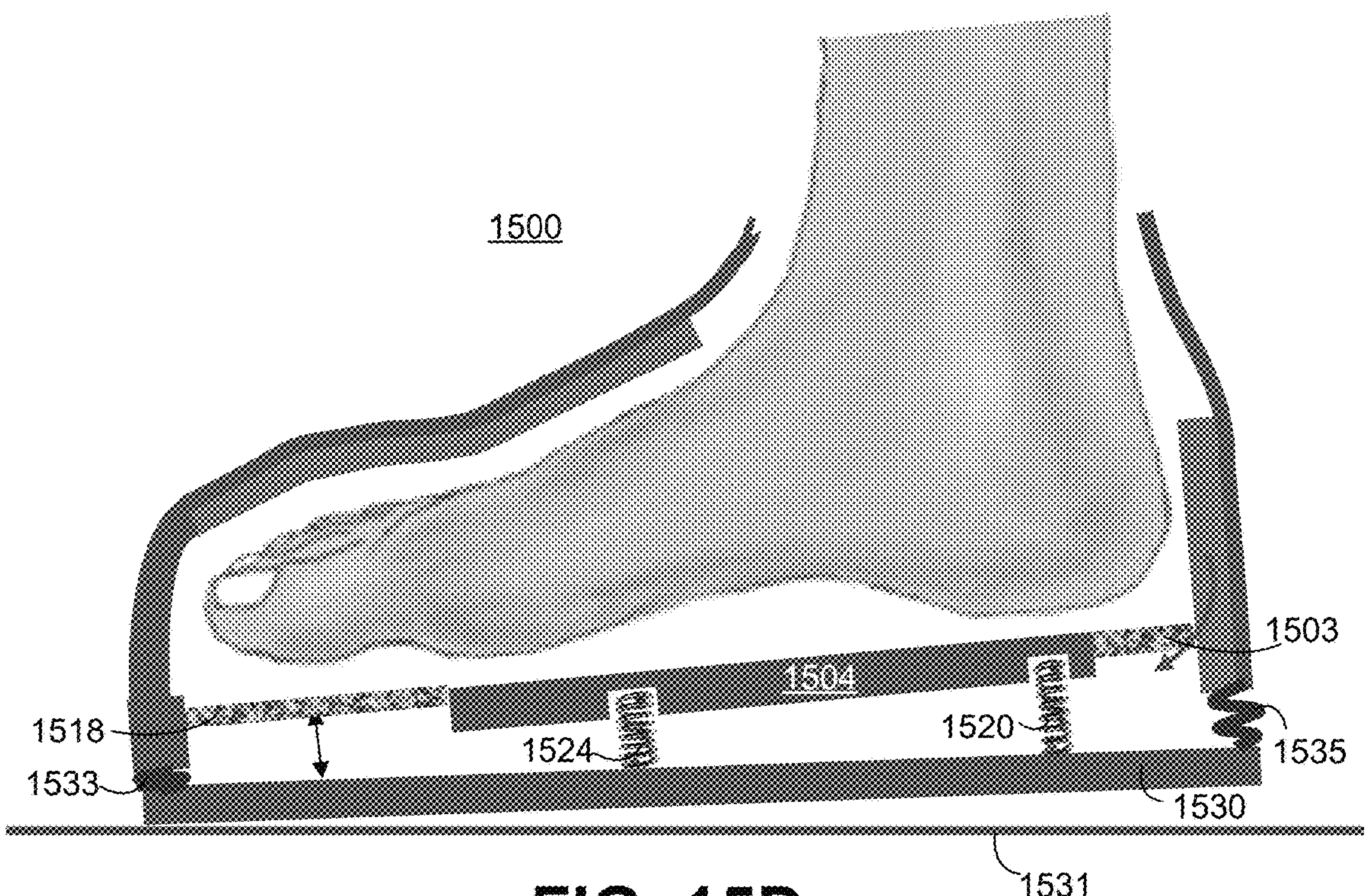

FIG. 15D

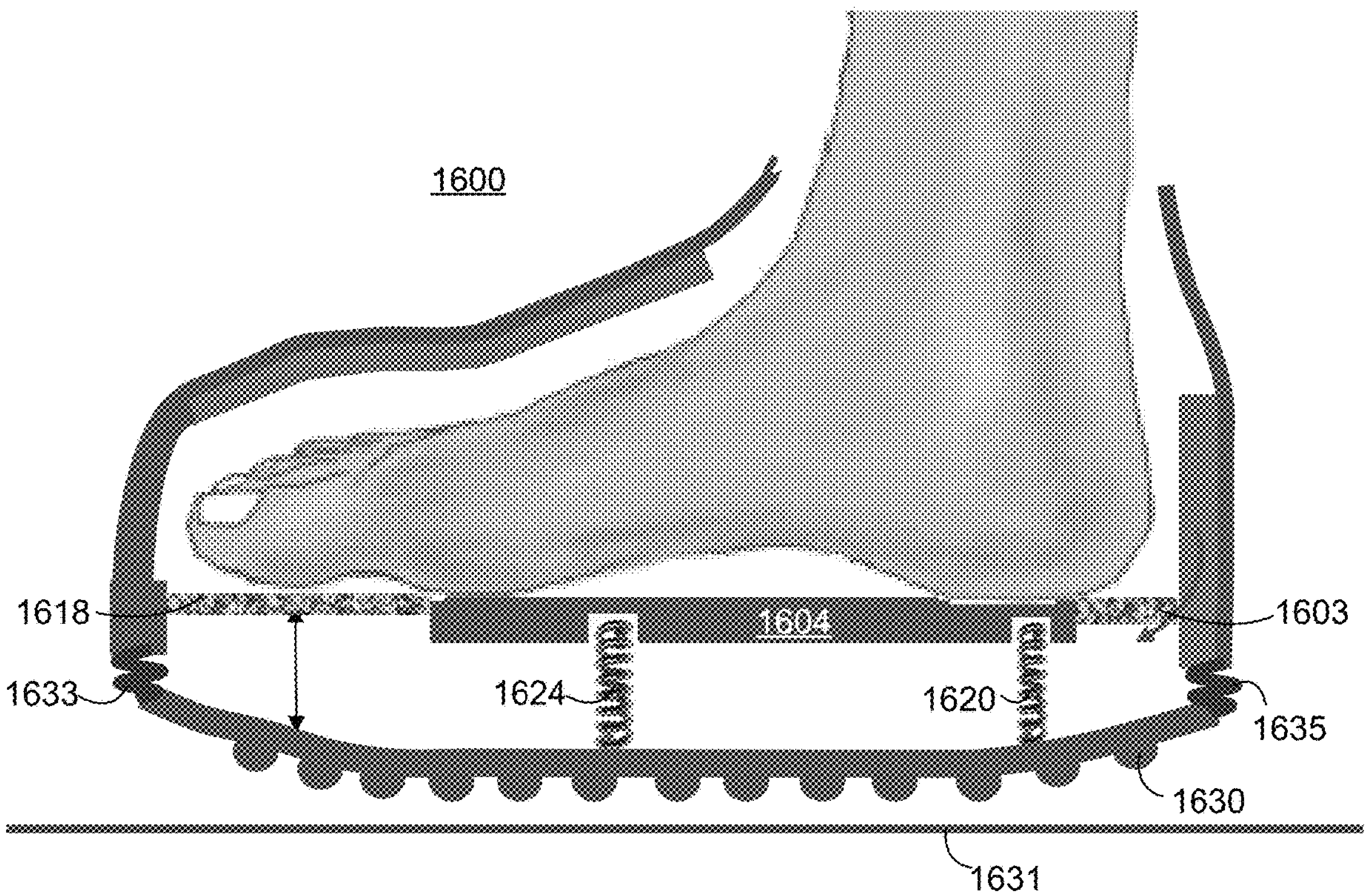

FIG. 16

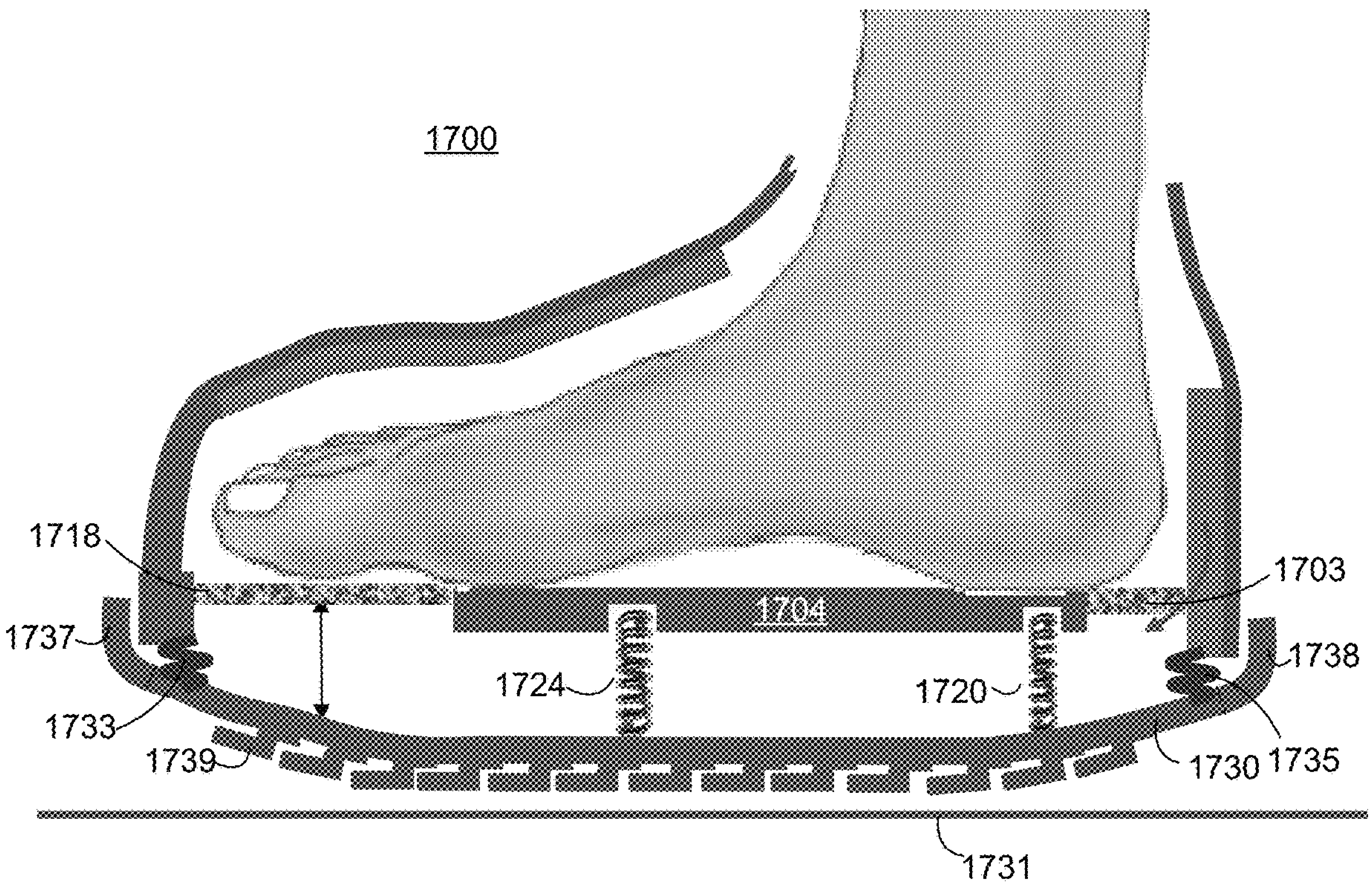
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FIG. 17

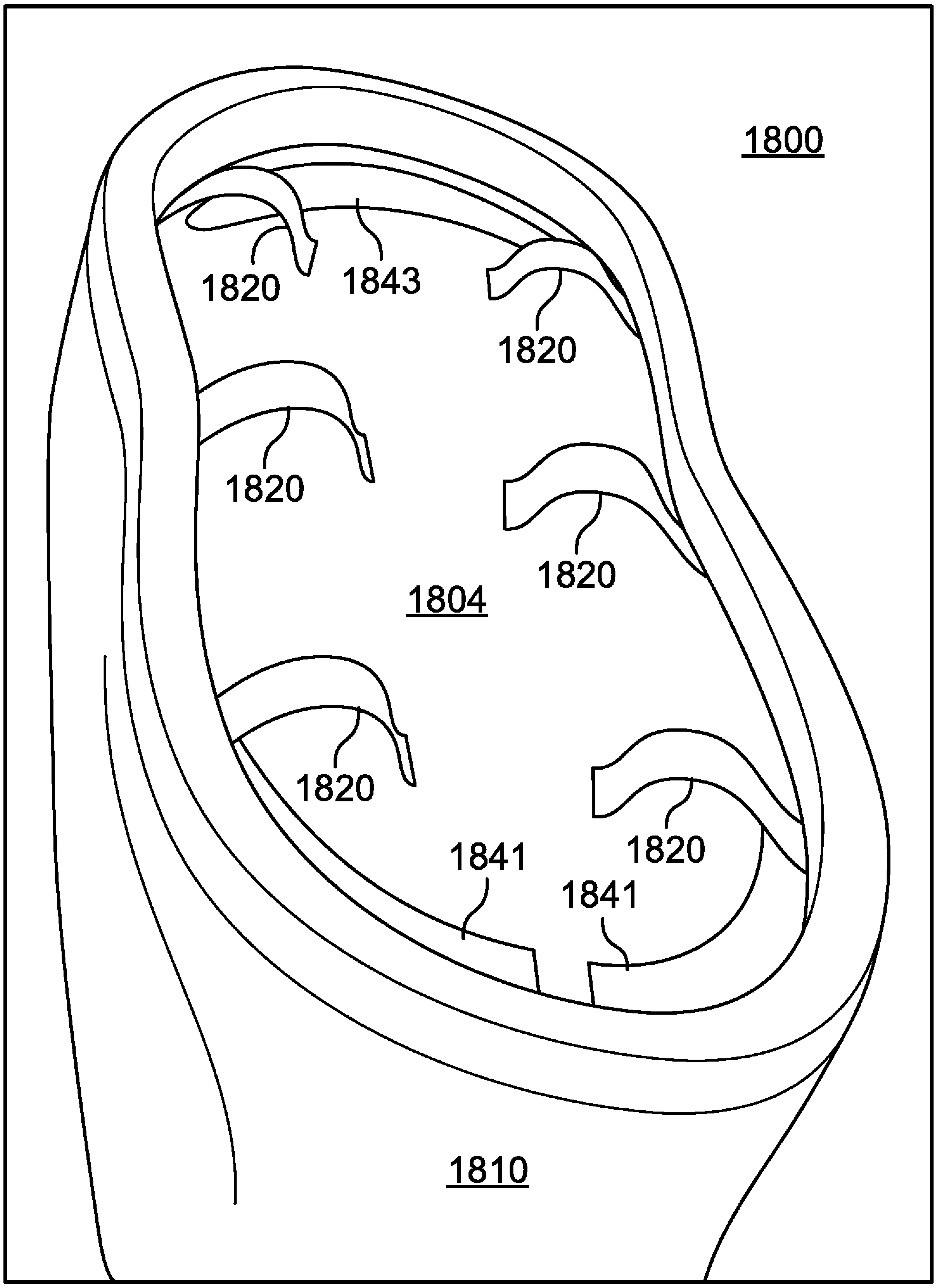

FIG. 18

MECHANICAL VENTILATION SYSTEM AND DEVICE FOR FOOTWEAR

CROSS-REFERENCES TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 62/366,431, filed Jul. 25, 2016, the entire disclosure of which is hereby incorporated by reference.

FIELD

The present disclosure relates generally to the ventilation of footwear, and more specifically to a mechanical ventilation system for footwear that produces enhanced airflow with every step.

BACKGROUND

Footwear comes in many different forms, including boots, formal shoes, sneakers, tennis shoes, moccasins, running shoes, sandals, heels, and other suitable forms. Many types of footwear are tight fitting and completely enclosed, which result in a lack of airflow. This lack of airflow can cause stale air to accumulate throughout the day inside of the footwear. To eliminate this problem, designs have been created that refresh the air inside of the footwear, including the addition of membranes to the outside of the footwear and ventilation systems. However, these solutions remain mostly ineffective, creating a need for new ventilation systems that effectively allow air to flow out of footwear.

SUMMARY

Systems and devices are described for creating a more effective mechanical ventilation system for footwear.

For example, a mechanical ventilation system for a piece of footwear may include a sole. The sole may be located at a bottom of the piece of footwear. The sole may be configured to be in contact with a ground or a surface that the piece of footwear is used to walk, run, or stand on. A portion (or a majority) of the sole may be configured to be flexible and deformable by the foot. A majority of the sole may refer to more than 50% of the sole. In some examples, the sole includes a first portion and a second portion, where the first portion of the sole is flexible. In such examples, the first portion of the sole may be thinner than the second portion of the sole so that the second portion can protect the first portion from wear and tear. In other examples, the second portion of the sole is configured to be coupled with a rigid material (e.g., ceramic or engineered plastic) to protect the first portion from wear and tear. In some examples, a portion of the sole is replaceable.

The mechanical ventilation system may further include an air reservoir positioned between a foot bed of the footwear and the sole. The foot bed may be a substantially rigid surface that a foot is in contact with when the foot is inside of the piece of footwear. In some examples, the air reservoir may be an opening that is defined by the foot bed and the sole. The air reservoir may be configured to occupy a majority of the space between the foot bed and the sole. For example, the air reservoir may occupy more than 50% of the space between the foot bed and the sole. In some examples, a portion of the foot bed is configured to be flexible and deformable by the foot.

The air reservoir may include an air intake opening positioned at a heel portion (sometimes referred to as a back portion) of the foot bed and an air exhaust opening positioned at a toe portion (sometimes referred to as a front portion) of the foot bed. The heel portion may be near where a heel of the foot may be located when the foot is inside of the piece of footwear. For example, the heel portion may be a portion between a back of the foot bed and a middle of the foot bed, where the back and the middle are in relation to a length of the piece of footwear. The toe portion may be near where one or more toes of the foot may be located when the foot is inside of the piece of footwear. For example, the toe portion may be a portion between a front of the foot bed and a middle of the foot bed, where the front and the middle are in relation to a length of the piece of footwear. In some examples, the air exhaust opening is a hollow conduit structure leading from a front opening of the air reservoir to a foot compartment of the footwear. In some examples, the air intake opening is a hollow conduit structure leading from a rear opening of the air reservoir to outside of the footwear.

In some examples, the sole may be configured to compress the air reservoir, causing air to flow out of the air exhaust opening when a force is applied by the foot. The sole may be further configured to decompress the air reservoir, causing air to flow into the air intake opening when the force is removed.

The mechanical ventilation system described above may allow a repetitive compression and decompression of the air reservoir to ventilate a foot compartment of the footwear by a flow of air into the air intake opening and out of the air exhaust opening. The foot compartment may be an area of a piece of footwear where the foot is located (sometimes referred to as housed).

The mechanical ventilation system may further include an elastic element coupled to an underside of the foot bed. The underside of the foot bed may be a top side of the air reservoir described above.

In some examples, the mechanical ventilation system may include a connecting juncture between the foot bed and the sole, where a portion of the connecting juncture is flexible and deformable by the foot.

In some examples, the sole is configured to enable peristaltic compression and deflation of the air reservoir when a user wearing the footwear walks and runs. In such examples, peristaltic deflation includes pushing air into the air reservoir using the air intake opening, and peristaltic compression includes bringing outside air into a foot compartment of the footwear using the air exhaust opening, where the outside air replaces stale air inside of the foot compartment to ventilate the foot compartment.

For another example, a mechanical ventilation system can include an air reservoir that is almost as large as the entire shoe under the footwear's foot bed (also interchangeable known as foot platform or substantially rigid surface). In some examples, the air reservoir can be connected to a foot compartment of the footwear that houses a foot of a user. The air reservoir can be compressed using a movable part that circulates air in the footwear with every step. As used herein, the word "movable part" can be referred to as an "actuator." The movable part can be relatively small, extending into the air reservoir, and able to compress and inflate the air reservoir. Movement of the movable part can cause a large effective compressible area of the air reservoir to release fresh air near the toes of a foot to flush stale air out of the footwear. The movable part can be partially or fully under a substantially rigid surface, such as the footwear's foot bed, allowing for movement of the movable part while still providing support for the foot with the substantially rigid surface. In some embodiments, when the movable part

is compressed, depressed, or pushed in a downward direction, the movable part can force air out of the air reservoir through an exhaust opening near the toes of the foot, flushing bad or stale air out through the top of the footwear. The rear portion of a foot (e.g., a heel of the foot) can apply the force, pressure or weight, to compress (or depress) the movable part.

Provided are mechanical ventilation systems for footwear. In some implementations, a mechanical ventilation system can include an air reservoir positioned between a foot bed of the footwear and a sole of the footwear. In some examples, the air reservoir can include an air intake opening and an exhaust opening, each connected to a foot compartment of the footwear. In such examples, the foot compartment can be configured to house a foot of a user.

The mechanical ventilation system can further include an actuator (sometimes referred to herein as a movable part). The actuator can be configured to be depressible when weight is applied to the actuator. A portion of the actuator can extend into the air reservoir such that movement of the actuator facilitates at least one or more of intake of air into the air reservoir through the air intake opening and exhaust of air out of the air reservoir through the exhaust opening. A portion of the actuator can be positioned to be depressible by a heel of the foot, a ball of the foot, another area of the foot, or any combination thereof.

In some examples, the actuator (or movable part) can include a front actuator portion and a rear actuator portion. In such examples, the front actuator portion can be positioned to be depressible by a ball of the foot, and the rear actuator portion can be positioned to be depressible by a heel of the foot. In some examples, when the rear actuator portion is depressed in a downward direction by the heel of the foot, the air intake opening of the air reservoir can be at least partially sealed and movement of the actuator can force air to flow in a direction from the rear actuator portion toward the front actuator portion and out of the exhaust opening of the air reservoir.

In some examples, when the front actuator portion is compressed in a downward direction by the ball of the foot while the rear actuator portion is compressed in the downward direction by the heel of the foot, the exhaust opening of the air reservoir can be at least partially sealed and the actuator can overcome the force of the elastic element to cause the actuator to move in a downward direction, forcing air to flow in a direction from the rear actuator portion toward the front actuator portion and out of the exhaust opening of the air reservoir. In some examples, when the rear actuator portion is uncompressed in an upward direction while the front actuator portion is compressed in a downward direction, the air intake opening of the air reservoir can be at least partially unsealed, allowing air to flow into the air reservoir. In some examples, when the rear actuator portion is uncompressed in an upward direction and the front actuator portion is uncompressed in an upward direction, the air intake opening of the air reservoir can be open, allowing air to flow into the air reservoir

In some implementations, the mechanical ventilation system can further include one or more elastic elements. In some examples, an elastic element can be coupled to an underside of the actuator. In such examples, an additional elastic element can also be coupled to the underside of the actuator. In some examples, the additional elastic element can be located in a different position than the elastic element.

In some implementations, the actuator can further include an additional extension portion. In such implementations, the additional extension portion can be coupled to at least one or more of the front actuator portion and the rear actuator portion. In some examples, the additional extension portion can be located at least partially under a substantially rigid surface, creating an additional air reservoir. In some examples, the substantially rigid surface can be separate from the foot bed. In such examples, at least one of the front actuator portion and the rear actuator portion can each include an interior hollow region that connects the air reservoir and the additional air reservoir.

In some implementations, a mechanical ventilation system can include a substantially rigid surface. In such implementations, the substantially rigid surface can be configured to support at least a portion of a foot. The mechanical ventilation system can further include a movable part that includes a front actuator portion, an extension portion, and a rear actuator portion. In some examples, the front actuator portion can be positioned at a front portion of the footwear. In such examples, the front actuator portion can be compressible in an upward direction by a surface. In some examples, the extension portion can be located at least partially under the substantially rigid surface. In some examples, the rear actuator portion can be positioned at a rear portion of the footwear. In such examples, the rear actuator portion can be compressible in the upward direction by the surface.

In some implementations, the mechanical ventilation system can further include (1) an elastic element coupled to the movable part and the substantially rigid surface and (2) an air reservoir. In some examples, the air reservoir can include an air intake opening and an exhaust opening. In some examples, when the rear actuator portion is compressed in the upward direction, the air intake opening of the air reservoir can be at least partially sealed and the extension portion can overcome a force of the elastic element to cause the extension portion to move in the upward direction, forcing air to flow in a direction from the rear actuator portion toward the front actuator portion and out of the exhaust opening of the air reservoir.

In some implementations, the mechanical ventilation system can be included in a shoe. The shoe can include a front actuator portion, an extension portion, and a rear actuator portion. The front actuator portion can be positioned at a front portion of the sole. In some examples, the front actuator portion can be compressible in an upward direction by a surface (e.g., the ground). In some examples, the extension portion can be located at least partially under a substantially rigid surface. In such examples, the substantially rigid surface can be configured to support at least a portion of a foot. In some examples, the rear actuator portion can be positioned at a rear portion of the sole. In such examples, the rear actuator portion can be compressible in the upward direction by the surface.

In some implementations, the shoe can further include an elastic element coupled to the sole and the substantially rigid surface. In some examples, the shoe can further include an air reservoir. In such examples, the air reservoir can include an air intake opening and an exhaust opening.

In some examples, when the rear actuator portion is compressed in the upward direction, the air intake opening of the air reservoir can be at least partially sealed and the extension portion can overcome a force of the elastic element to cause the extension portion to move in the upward direction, forcing air to flow in a direction from the rear actuator portion toward the front actuator portion and out of the exhaust opening of the air reservoir.

In some implementations, a mechanical ventilation system for footwear can include an air reservoir positioned between a foot bed of the footwear and a sole of the footwear. In such examples, the air reservoir can include an air intake opening and an exhaust opening connected to a foot compartment of the footwear. In some examples, the foot compartment can be configured to house a foot of a user. In some examples, the mechanical ventilation system can further include a sole. In such examples, the sole can be configured to compress the air reservoir when the user wearing the footwear steps on a surface with the footwear. In some examples, the sole can be configured to decompress the air reservoir when the user wearing the footwear lifts the footwear from the surface. In such examples, the movement of the sole repetitively expands and contracts a volume of the air reservoir to ventilate the foot compartment.

In some implementations, the mechanical ventilation system of claim can further include an elastic element coupled to an underside of the foot bed. In some examples, a portion of the sole is configured to be flexible and deformable by the foot of the user. In some implementations, the mechanical ventilation system can further include a connecting juncture between the foot bed and the sole. In such implementations, a portion of the connecting juncture can be flexible and deformable by the foot of the user. In some examples, a portion of the foot bed can be configured to be flexible and deformable by the foot of the user.

In some implementations, the sole can be configured to enable peristaltic compression and deflation of the air reservoir when the user wearing the footwear is pressed against a surface (e.g., when walking or running). In such implementations, peristaltic deflation can include pushing air into the air reservoir using the air intake opening, and peristaltic compression can include bringing outside air into the foot compartment using the exhaust opening. In some examples the outside air can replace stale air inside of the foot compartment to ventilate the foot compartment.

In some implementations, the sole can include a first portion and a second portion. In such implementations, the first portion of the sole can be flexible. In some examples, the first portion of the sole can be thinner than the second portion of the sole. In some examples, the second portion can be configured to be thicker than the first portion to protect the first portion from wear and tear against a surface. In such examples, the second portion of the sole can be replaceable.

In some examples, the sole can include a first portion and a second portion. In such examples, the first portion of the sole can be flexible and configured to be coupled with a rigid material (e.g., ceramic or engineered plastic) to protect the first portion from wear and tear against a surface. In such examples, the second portion of the sole can be replaceable.

In some implementations, the exhaust opening can be a hollow conduit structure leading from a front opening of the air reservoir to the foot compartment. In some examples, the air intake opening can be a hollow conduit structure leading from a rear opening of the air reservoir to outside of the footwear.

In other embodiments, a mechanical ventilation system for footwear can include a movable part that comprises one or more actuator portions (or contact areas) that are affected or actuated by a foot of a user. The movable part can also include an "extension," or "extension portion," that extends the air reservoir under the foot bed (which can be a substantially rigid surface). The one or more actuator portions can be compressed, depressed, or moved in a downward direction by different portions of a foot. In some embodiments, one or more portions of the movable part can be held against the foot bed, a substantially rigid surface, by one or more elastic elements that are designed to compress when a downward force of a foot is applied to such portions of the movable part. The terms compress and depress can be used interchangeable in this specification.

In some examples, when a user takes a step, the heel of the foot can cause the footwear to strike the walking surface (e.g., the ground or other surface upon which a user walks). During a heel strike, a back portion of the foot can cause an actuator portion (e.g., a rear contact area) of the movable part to compress (or lower/depress) and overcome a force of one or more elastic elements. Compression or depression of the actuator can cause an intake opening of an air reservoir to be at least partially eliminated, and also cause an extension of the movable part to move in a downward direction in the air reservoir. The downward movement of the extension and the actuator can force air to flow in a direction from the extension toward an exhaust opening of the air reservoir in the front of the footwear. When the footwear is then brought to a neutral position as the user continues the step (e.g., the front of the footwear comes in contact with the walking surface along with the back of the foot), the movable part can be depressed or lowered in the air reservoir as the force of the one or more elastic elements is overcome by the foot, causing any remaining air in the air reservoir to be released through the exhaust opening.

When the ankle of the foot is then lifted to raise the heel or back portion of the footwear off of the walking surface, the movable part can raise in an upward direction to resume its natural state, which opens the intake opening. In such cases, the movable part might not be compressed or depressed. The opening of the intake opening can allow fresh air to fill the air reservoir with fresh air and the process repeats.

In some embodiments, one or more partially hollow portions can be used to allow for multiple levels of air reservoirs to minimize a depth that the movable part must travel to displace a particular amount of air. An embodiment can have multiple portions under multiple substantially rigid surfaces to allow for the amount of air moved to be approximately equal to a change in distance by the movable part multiplied by each level.

In some embodiments, the sole can be made with a flexible material and can be sized almost as large as the shoe such that it can be used to compress or inflate a large area of the air reservoir with a relatively small vertical travel, and there is still substantial air movement inside the shoe for ventilation. In some embodiments, the sole can be flexible to bring in movement of air from outside to inside in a substantially single direction by peristaltic compression and inflation of the air reservoir when the user is walking or running.

This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification of this patent, any or all drawings, and each claim.

The foregoing, together with other features and embodiments, will be described in more detail below in the following specification, claims, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Illustrative embodiments of the present invention are described in detail below with reference to the following drawing figures:

FIG. 1A is a bottom view illustrating an example of a mechanical ventilation system for footwear.

FIG. 1B is a bottom view illustrating another example of a mechanical ventilation system for footwear, in accordance with an embodiment of the present disclosure.

FIG. 2 is a side view illustrating an example of a mechanical ventilation system with an actuator near a back of a footwear, in accordance with an embodiment of the present disclosure.

FIG. 3A is a side view illustrating another example of a mechanical ventilation system for footwear in a neutral position, in accordance with an embodiment of the present disclosure.

FIG. 3B is a side view illustrating another example of a mechanical ventilation system for footwear in a first position, in accordance with an embodiment of the present disclosure.

FIG. 3C is a side view illustrating another example of a mechanical ventilation system for footwear in a second (neutral) position, in accordance with an embodiment of the present disclosure.

FIG. 3D is a side view illustrating another example of a mechanical ventilation system for footwear in a third position, in accordance with an embodiment of the present disclosure.

FIG. 3E is a side view illustrating another example of a mechanical ventilation system for footwear in a fourth position, in accordance with an embodiment of the present disclosure.

FIG. 4A is a side view illustrating an example of a mechanical ventilation system with an air flow escape path in a single direction air flow mechanism, in accordance with an embodiment of the present disclosure.

FIG. 4B is a side view illustrating an example of a mechanical ventilation system with an air flow input path in a single direction air flow mechanism, in accordance with an embodiment of the present disclosure.

FIG. 5A is a top view of an example of an air vent apparatus for a mechanical ventilation system with an air flow escape path in a single direction, in accordance with an embodiment of the present disclosure.

FIG. 5B is a bottom view of an air vent apparatus, in accordance with an embodiment of the present disclosure.

FIG. 5C depicts an air intake opening and exhaust openings for an air vent layer, in accordance with an embodiment of the present disclosure.

FIG. 5D depicts an air intake opening in a piece of footwear, in accordance with an embodiment of the present disclosure.

FIG. 5E depicts an exhaust tunnel in a piece of footwear, in accordance with an embodiment of the present disclosure.

FIG. 5F is a perspective view of an exhaust tunnel, in accordance with an embodiment of the present disclosure.

FIG. 5G is a front view of an exhaust tunnel, in accordance with an embodiment of the present disclosure.

FIG. 6 is a side view illustrating an example of a mechanical ventilation system with a sealed foot platform in a single direction air flow mechanism, in accordance with an embodiment of the present disclosure.

FIG. 7 is a side view illustrating an example of a mechanical ventilation system with different locations for portions of a movable part in a single direction air flow mechanism, in accordance with an embodiment of the present disclosure.

FIG. 8A-FIG. 8B illustrate an example of a compression (or depression) depth of a movable part, before and after compression/depression, in a single direction mechanical ventilation system, in accordance with an embodiment of the present invention.

FIG. 9A-FIG. 9B are side views illustrating another example of a mechanical ventilation system, before and after compression/depression of a movable part, in accordance with an embodiment of the present disclosure.

FIG. 10 illustrates another example of a mechanical ventilation system that enhances air flow by taking advantage of parallel air reservoirs, in accordance with an embodiment of the present disclosure.

FIG. 11A is a side view illustrating another example of a mechanical ventilation system for footwear in a raised position, in accordance with an embodiment of the present disclosure.

FIG. 11B is a side view illustrating another example of a mechanical ventilation system for footwear in a lowered position, in accordance with an embodiment of the present disclosure.

FIG. 12 is a side view illustrating another example of a mechanical ventilation system for footwear in a lowered position, in accordance with an embodiment of the present disclosure.

FIG. 13A is a side view illustrating another example of a mechanical ventilation system for footwear in a raised position, in accordance with an embodiment of the present disclosure.

FIG. 13B is a side view illustrating another example of a mechanical ventilation system for footwear in a lowered position, in accordance with an embodiment of the present disclosure.

FIG. 14A is a side view illustrating another example of a mechanical ventilation system for footwear in a first (raised) position, in accordance with an embodiment of the present disclosure.

FIG. 14B is a side view illustrating another example of a mechanical ventilation system for footwear in a second position, in accordance with an embodiment of the present disclosure.

FIG. 14C is a side view illustrating another example of a mechanical ventilation system for footwear in a third (lowered) position, in accordance with an embodiment of the present disclosure.

FIG. 14D is a side view illustrating another example of a mechanical ventilation system for footwear in a fourth position, in accordance with an embodiment of the present disclosure.

FIG. 15A is a side view illustrating another example of a mechanical ventilation system for footwear in a first (raised) position, in accordance with an embodiment of the present disclosure.

FIG. 15B is a side view illustrating another example of a mechanical ventilation system for footwear in a second position, in accordance with an embodiment of the present disclosure.

FIG. 15C is a side view illustrating another example of a mechanical ventilation system for footwear in a third (lowered) position, in accordance with an embodiment of the present disclosure.

FIG. 15D is a side view illustrating another example of a mechanical ventilation system for footwear in a fourth position, in accordance with an embodiment of the present disclosure.

FIG. 16 is a side view illustrating another example of a mechanical ventilation system for footwear that combines other embodiments, in accordance with an embodiment of the present disclosure.

FIG. **17** is a side view illustrating another example of a mechanical ventilation system for footwear with alterations to a sole, in accordance with an embodiment of the present disclosure.

FIG. **18** is a bottom view illustrating an example of compressible elements for a mechanical ventilation system, in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

In the following description, for the purposes of explanation, specific details are set forth in order to provide a thorough understanding of embodiments of the disclosure. However, it will be apparent that various embodiments may be practiced without these specific details. The figures and description are not intended to be restrictive.

The ensuing description provides exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of the disclosure. Rather, the ensuing description of the exemplary embodiments will provide those skilled in the art with an enabling description for implementing an exemplary embodiment. It should be understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the disclosure as set forth in the appended claims.

Footwear often lacks effective airflow when worn by users, causing stale air to accumulate inside the footwear. Many footwear designs attempt to eliminate this problem by adding membranes to the outside of the footwear and ventilation systems that constantly refresh the air inside of the footwear. Unfortunately, membranes are not always possible, including when the footwear must be sealed to the outside. Ventilation systems are either powered electronically or mechanically. An example of an electronic ventilation system is a built-in miniature fan that is powered by batteries. However, such a design may not be suitable for hazardous environments, including when gas leaks are present. Furthermore, electronic ventilation systems may malfunction, leaving the systems inoperable.

Mechanical ventilation systems can provide a more effective system to allow air to flow out of footwear. FIG. **1**A illustrates a bottom view showing an example of a mechanical ventilation system **100** for an item of footwear **102**. As shown, a foot **104** can be inside a foot compartment of footwear **102**. The mechanical ventilation system **100** can include an actuator **106**. The actuator **106** can be located near a heel of the foot **104**. The actuator **106**, when depressed, can transfer air to the front of the footwear **102**. In particular, when the foot **104** presses on the actuator **106**, air can travel in the direction shown by the arrows. In addition, the air can be directed through one or more rigid channels **113** when the actuator **106** is activated. The one or more rigid channels **113** can support the foot **104**. The system in FIG. **1**A can have limited effectiveness because the volume of the air displaced can be just the size of the actuator **106** (e.g., due to only the region of the actuator **106** around the heel being compressible).

Mechanical ventilation systems can be improved by using space between the foot bed and the sole of the footwear to collect air, circulate air, and ventilate the foot compartment of the footwear. FIG. **1**B is a bottom view illustrating another example of a mechanical ventilation system **150** for footwear, in accordance with an embodiment of the present disclosure. The footwear includes air reservoir **108** positioned between the foot bed and the sole for collecting air and circulating air to the foot compartment. The actuator **106** can be connected to an extension that extends across the air reservoir **108**. The extension can increase the area that is displaced when the actuator **106** is compressed, depressed, or lowered. In such examples, the actuator is not confined to moving air directly under the heel of the foot **104**. When weight is applied to the actuator **106**, the actuator **106** is compressed (sometimes referred to as depressed). Movement of the actuator **106** and the extension (which extends into the air reservoir **108**) displaces air in the air reservoir **108**. Therefore, when the actuator **106** is lowered, the air can come from under both the actuator **106** and the extension. The displaced air can then exit between the toes of the foot **104**, which is an area where ventilation is desired. As can be seen, the air displaced is much larger in the mechanical ventilation system **150** as compared the mechanical ventilation system **100**, and is thus more effective.

FIG. **2** is a side view illustrating an example of a mechanical ventilation system **200** for footwear, in accordance with an embodiment of the present disclosure. The mechanical ventilation system can include an air reservoir **208** and a movable part **202**. The air reservoir **208** can be positioned between a foot bed **204** (interchangeable a substantially rigid surface) and a sole **230** of the footwear. For example, the air reservoir **208** may be a space that is defined by the foot bed **204** and the sole **230**. The sole **230** may be a section forming an underside of a piece of footwear (sometimes including a heel when the heel forms a distinct part). For example, the sole **230** may include a bottom portion of the piece of footwear that is in contact with a ground or surface while the footwear is being used to walk or run on. The movable part **202** can be mobile. The movable part **202** can include an extension portion **214** that can extend into the air reservoir **208** and be at least partially covered by the foot bed **204**. The movable part **202** can further include an actuator **212** (or contact area). One of skill in the art will appreciate that the movable part **202** can be a different size or shape than that shown in FIG. **2**. In addition, movable part **202** can be covered more or less by the foot bed **204** than that shown. While FIG. **2** illustrates a top of the actuator **212** above the foot bed **204**, the top of the actuator **212** can be level with the foot bed **204** in some embodiments. In other embodiments, the actuator **212** can raise above the foot bed **204** in more than one place. In other embodiments, the actuator **212** can be located in a different location than shown in FIG. **2**. For example, the actuator **212** can be located near the center of the footwear. The actuator **212** can also be located in other portions of the footwear (e.g., near the front of the footwear).

The foot bed **204** can be rigid, providing an area that the foot can rest upon while the movable part **202** remains mobile. As used herein, the term rigid (or "substantially rigid") can refer to a surface that provides foot support to a user and that does not substantially alter shape when the user applies the force of their body weight to the surface. For example, the foot bed **204** may move slightly in a downward direction when the user is standing on the foot bed **204**, but does not move or alter shape so much that the user is not provided with foot support. For example, the foot bed **204** can provide the support that the sole **230** of a typical item of footwear provides. The area under the foot bed **204**, the extension portion **214**, and the actuator **212** can include an air reservoir **208**. When a user takes a step, the force of the foot can compress the actuator **212** and push the extension portion **214** downward. The operation of the actuator **212**, the extension portion **214**, and the air reservoir **208** can allow for more air to be displaced, which provides better ventilation. By using the combination of the actuator **212**, the extension portion **214**, and the air reservoir **208**, the mechanical ventilation system **200** can have access to more displaced air when the movable part **202** is activated. In addition, the mechanical ventilation system **200** can achieve improved exit velocity of the displaced air in relation to where fresh air is needed. The improved exit velocity can be achieved because the air is displaced from a location near the toes.

The movable part **202** can be raised in an upward direction by an elastic element **206** when the foot is lifted up and the actuator **212** is not under a force that opposes gravity. When the movable part **202** is raised in an upward direction, air can fill the air reservoir **208** through an air intake opening (or "intake opening") (illustrated as air intake opening **303** in FIG. **3**A, but not illustrated in FIG. **2**). The air intake opening may be positioned in a heel portion of the foot bed, the heel portion where a heel of a foot would be located when the foot is inserted into a piece of footwear. The heel portion may be between a side of the foot bed that is located at the back of the piece of footwear and a middle of the foot bed relative to a front and a back of the footwear. The elastic element **206** can provide enough force to push the movable part **202** toward, or in contact with, the foot bed **204** when the foot is lifted. In some examples, the elastic element **206** can include a metal helical spring. However, while the elastic element **206** is shown as a metal helical spring in FIG. **2**, the elastic element **206** can include any elastic element that provides a force to the movable part **202** in an upward direction, as described above. Examples of elastic elements can include, but are not limited to, a spring (e.g., metal, plastic, or springs made of other suitable materials), magnets, memory foams, or any other elastic or resistive material or item. The elastic element **206** can also be located in a different location than shown in FIG. **2**. For example, the elastic element **206** can be located toward the middle of the movable part **202**. Further, while two elastic elements are shown in FIG. **2**, a single elastic element, or more than two elastic elements, can be provided to apply an upward force to the movable part **202**. In such an example, the force provided by the elastic elements would be split among the number of elastic elements. The elastic element **206** can also be bigger or smaller than shown in FIG. **2**.

Once the foot moves in a downward direction, the actuator **212** and the extension portion **214** of the movable part **202** can overcome the force of the elastic element **206** and move in a downward direction. When the movable part **202** is moved in the downward direction by the foot, air can be pushed through the air reservoir **208** along the path indicated by the arrows shown in FIG. **2**. The air eventually can be released at an exhaust opening **210** (or air exhaust opening) that is located near the toes of the foot. The location of the exhaust opening **210** can be near the front of the footwear. For example, the exhaust opening **210** may be positioned in a toe portion of the foot bed, the toe portion where toes of a foot would be located when the foot is inserted into a piece of footwear. The toe portion may be between a side of the foot bed that is located at the front of the piece of footwear and a middle of the foot bed relative to a front and a back of the footwear.

The path and size of the exhaust opening **210** can be different than that shown in FIG. **2**. For example, the path can be narrower or wider than shown, or the path can be straight or have one or more bends in it to account for the shape of certain footwear. In addition, the exhaust opening **210** can be located in a different place in the footwear, or can be narrower or wider than that shown.

In some embodiments, a movable part, similar to the movable part **202** in FIG. **2**, can include more than one actuator as illustrated in FIG. **3**A. FIG. **3**A is a side view illustrating another example of a mechanical ventilation system **300** for footwear in a first (neutral) position, in accordance with an embodiment of the present disclosure. The footwear can house a foot resting on a substantially rigid surface **304**. While the substantially rigid surface **304** can move nominally due to the materials it is made of, a purpose of the substantially rigid surface can be to provide support for the foot. Thus, any movement or compression of the substantially rigid surface can be due to the materials involved and not because the substantially rigid surface **304** is meant to displace air for the mechanical ventilation system **300**. The rigidity of the substantially rigid surface **304** can be important to provide stability for the footwear. For example, the footwear can be worker's boots, in which case a person might climb ladders. In such an example, a fixed foot platform can be advantageous compared to a compressible platform. However, some compression is inevitable, due to the nature of materials and for purposes such as cushioning to provide comfort for the user of the footwear. In addition, the substantially rigid surface **304** can be more than one contiguous surface. For example, the substantially rigid surface **304** can be broken up into pieces or segments that still support the foot, as shown in FIG. **7**.

The mechanical ventilation system **300** can also include a movable part **302**. The movable part **302** can include a front actuator portion **316** and a rear actuator portion **312**. The front actuator portion **316** and the rear actuator portion **312** can be compressible (e.g., in a downward direction). The movable part **302** can also include a middle section, referred herein as an extension portion (or an "extension **314**"). The extension **314** can be located under the substantially rigid surface **304**. However, one of skill in the art will appreciate that the extension **314** can be located in a different position, not under the substantially rigid surface **304**. In other embodiments, the extension **314** can be located a greater or lesser amount under the substantially rigid surface **304**. In some embodiments, the mechanical ventilation system **300** can provide stability to a user because the rear actuator portion **312** and the front actuator portion **316** are relatively small parts in contact with the user of the footwear. The rear actuator portion **312** and/or the front actuator portion **316** can be padded with soft materials to function as cushion for a foot. The depth that the movable part **302** can lower can depend on a z-depth **322**. The z-depth **322** can be optimized for a reasonable air flow while not creating an excessive movement of the rear actuator portion **312** and/or the front actuator portion **316**. In some embodiments, an illustrative z-depth can range from 0.5 mm to 5 inches. One of ordinary skill in the art will appreciate that the movable part **302** can lower to other suitable z-depths.

The substantially rigid surface **304** can be supported by a series of columns **306**. The columns **306** can be coupled to a foot bed **330**, as shown in FIG. **3**A. In some embodiments, the substantially rigid surface **304** can be supported by a side or wall of the footwear instead of a column, as will be described further below. In some examples, the columns **306** can be hollow to allow ventilation of air to an area between the substantially rigid surface **304** and a foot. In some examples, to fit the movable part **302** around the columns **306**, the movable part **302** can include holes where the columns **306** are located to facilitate movement of the movable part **302** in upward and downward directions. In other examples, the columns **306** can be positioned such that they do not interfere with the movement of the movable part **302**.

Similar to the system shown in FIG. **2**, one or more elastic elements **320** and **324** (similar to the elastic element **206**) can provide tension for the movable part **302** (similar to the movable part **202**) in an upward direction. Elastic elements **320** and **324** can have elastic and/or pivoting properties. As seen in FIG. **3**, two separate elastic elements **320** and **324** can be positioned in different locations. By having two elastic elements **320** and **324**, with some distance between them along the extension **314**, actuators **312** and **316** can move independently as force is applied to the movable part **302**. However, one of skill in the art will appreciate that the particular locations of the elastic elements **320** and **324** can be changed, or that the number of elastic elements can either be increased or decreased depending on the particular type of elastic element and the amount of force required to oppose gravity.

The mechanical ventilation system **300** can further include an exhaust opening **318** that can allow the free flow of air both while the movable part **302** is lowered and while the movable part **302** is not operating (e.g., when the person is not walking). Air is allowed to enter the mechanical ventilation system **300** through an intake opening **303**, where the rear actuator portion **312** can at least partially close. The mechanical ventilation system **300** can be designed so that the air travels through the mechanical ventilation system **300** until it reaches the exhaust opening **318**, where air can exit towards the toes of the foot. The exhaust opening **318** can include an air-permeable surface through which air can escape. Examples of an air-permeable surface can include, but are not limited to, a mesh screen, a surface with holes, a membrane that allows the free flow of air, or any other material or element that allows air through but will also act as a surface for a foot's toes to rest on. The area of the exhaust opening **318** can be any material. In other embodiments the exhaust opening can be an open orifice for air to escape.

FIG. **3**B-FIG. **3**E show further side views of the mechanical ventilation system **300**, in accordance with an embodiment of the present disclosure. The different views shown in FIG. **3**B-FIG. **3**E illustrate a user during a walking motion. The movable part **302**, together with the movement during walking, enables a single direction air-flow, without the use of air valves commonly found in prior designs. This single direction air-flow mechanism is explained by dividing the walking movement into four positions.

The first position is illustrated by FIG. **3**B, which shows the beginning of the walking movement when the heel of a user's foot presses against the walking surface with the front of the foot slightly raised off of the walking surface (referred to herein as a "heel strike"). During the heel strike, the rear portion of the foot (e.g., the heel and/or other rear portion of the user's foot) causes the rear actuator portion **312** of the movable part **302** to lower to the foot bed **330**. In some embodiments, by lowering the rear actuator portion **312** to the foot bed **330**, the intake opening **303** can be closed off to the free flow of air. The elastic element **320**, which is closer to the rear actuator portion **312** than the elastic element **324**, can be compressed more than the elastic element **324**, which is closer to the front actuator portion **316**. The use of both elastic elements **320** and **324** divides the force applied to each elastic element **320**, **324** between the two, lessening the work of each individual elastic element **320**, **324**. In addition, each elastic element **320**, **324** has less torque applied to it as compared to if it were the only elastic element coupled to the movable part **302**.

Lowering of the rear actuator portion **312** can cause fresh air to flow through an air reservoir **308** in a direction from the rear actuator portion **312** to the front of the footwear toward the exhaust opening **318**. As the rear actuator portion **312** is lowered (or "compressed"), the front actuator portion **316** can be raised upward toward the substantially rigid surface **304**. By raising the front actuator portion **316**, the air flowing through the air reservoir **308** can escape through the exhaust opening **318** near the toes of a foot.

The second position is illustrated by FIG. **3**C, which shows the foot pressing the entire footwear to the walking surface. When the entire footwear is pressed to the walking surface, the mechanical ventilation system **300** can be put in a lowered position, where the rear actuator portion **312**, the extension **314**, and the front actuator portion **316** are lowered to the foot bed **330**. In addition, the elastic elements **320**, **324** can be compressed. When this occurs, the intake opening **303** continues to be closed by the rear actuator portion **312**. The remaining amount of air under the extension **314** can be forced out from the air reservoir **308** toward the front of the footwear through the exhaust opening **318**. In some embodiments, as described above, the columns **306** can be hollow. In such embodiments, air can travel from the air reservoir **308**, through the columns **306**, and to a middle area of the footwear through the columns **306** to further ventilate the foot. In some embodiments, when the movable part **302** of the mechanical ventilation system **300** is in the lowered position, a gap can be created between the movable part **302** and the substantially rigid surface **304**. For example, the gap can be present because the movement of the movable part **302** does not require the substantially rigid surface **304** to move. As previously described, the substantially rigid surface **304** can be somewhat movable to allow for cushioning, but any vertical movement of the rigid surface **304** is less as compared to the movable part **302**.

The third position, illustrated by FIG. **3**D, is the foot lifting up at the ankle, leaving the front of the foot on the walking surface and the heel lifted from the walking surface. When the user lifts up the foot at the ankle, the rear actuator portion **312** can be caused to move in an upward direction from the foot bed **330**. In such an example, the front actuator portion **316** can continue to be lowered toward or in contact with the foot bed **330**. The upward movement of the rear actuator **312** can cause the intake opening **303** to open. In addition, a portion of the air reservoir **308** can be shut off by the front actuator portion **316**, preventing air from escaping through the exhaust opening **318**. As a result of the exhaust opening **318** being shut-off from the air reservoir **308**, stale air can be prevented from flowing back into the air reservoir **308**. While the exhaust opening **318** is shut-off, the air reservoir **308** can be refilled by fresh air that is allowed to enter into the air reservoir **308** through the intake opening **303**. In such an example, the elastic element **324** can be fully compressed while the elastic element **320** can be either at least partially compressed or not compressed.

The fourth position of the walking movement, shown by FIG. **3**E, illustrates the entire foot being lifted from the walking surface. When the entire foot is lifted, the front actuator portion **316** can be raised in an upward direction from the foot bed **330**, which fully opens the air reservoir **308**. The air that entered through the intake opening **303** then fills the air reservoir **308** under the movable part **302**, completely refreshing the air supply in the mechanical ventilation system **300** so that the cycle can be restarted from the first position shown in FIG. **3**B when a new step is taken. In such an example, the elastic elements **320** and **324** can be uncompressed.

FIG. **4**A is an example of a mechanical ventilation system **400** with an air flow escape path in a single direction, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **400** can be similar to the mechanical ventilation system **300**. The mechanical ventilation system **400** can further include a front lining **440** and a front outer shell **442** that create a front air vent.

The front lining **440** can include holes or channels (not shown) that allow air to flow out of the footwear. The front lining **440** can be semi-rigid or rigid. For example, the front lining **440** can flex, but may not be substantially compressible, to allow the air permeable holes or channels to remain open when the footwear's laces are tied or when the person is walking. Meanwhile, a front outer shell **442** covers the front lining **440** to provide a water proof outer cover for the footwear. The front outer shell **442** can extend beyond the front lining **440** so that water cannot easily enter the front lining **440** and flow into the footwear through the holes or channels. The front outer shell **442** and the front lining **440** can be longer than that shown in FIG. **4**, such as for particular footwear, including work boots, water boots, fashion winter boots, or the like.

FIG. **4**B is an example of a mechanical ventilation system **401** with an air flow input path in a single direction, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **401** can be similar to the mechanical ventilation system **400**. The mechanical ventilation system **401** can further include a back lining **450** and a back outer shell **452** that create a back air vent. In some examples, the mechanical ventilation system **401** does not include the front lining **440** and/or the front outer shell **442**.

The back lining **450** can include holes or channels that allow air to flow into the footwear. The back lining **450** can be semi-rigid or rigid, similar to the front lining **440**. For example, the back lining **450** can flex, but may not be substantially compressible to allow the air permeable holes or channels to remain open when the user is walking. Meanwhile, the back outer shell **452** can cover the back lining **450** to provide a waterproof outer cover for the footwear. The back outer shell **452** can extend beyond the back lining **450** so that water cannot easily enter the back lining **450**. The back outer shell **452** and the back lining **450** can be longer than that shown in FIG. **4**B. Furthermore, the back lining **450** can be a multitude of shapes, such as a half-moon shape or a ring shape to surround the ankle and the base of the foot. Depending on the shape, an intake opening **403** can be bigger or smaller. For example, if the back lining **450** is curved away from the intake opening **403**, the intake opening **403** can be larger.

FIG. **5**A is a top view of an example of air vent apparatus **500** for a mechanical ventilation system with an air flow escape path in a single direction, in accordance with an embodiment of the present disclosure. The mechanical ventilation system can be included below an outer shoe layer **510**, with a sole below the mechanical ventilation system. The outer shoe layer **510** can include a foot opening **515** that receives a foot of a user. A back inner shoe layer **520** and a front inner shoe layer **530** can be included inside of the outer shoe layer **510**. While the outer shoe layer **510** is illustrated as semitransparent to better show the internal components, the outer shoe layer **510** can be solid and not show the components inside.

The back inner shoe layer **520** can create one or more pathways for air to flow from outside of the outer shoe layer **510** to inside of the outer shoe layer **510** as shown by arrow **540**. In some examples, the air can flow between the back inner shoe layer **520** and the outer shoe layer **510** through the foot opening **515**. The one or more pathways can be created by having a distance between the back inner shoe layer **520** and the outer shoe layer **510**. In one illustrative example, the distance can be one centimeter. However, a person of ordinary skill in the art will recognize that the distance can be less or more than one centimeter. In some embodiments, the distance can vary along a length of the back inner shoe layer **520**. For example, the distance can be larger near a back of the footwear and smaller near a front of the back inner shoe layer **520**, as illustrated in FIG. **5**A.

In some embodiments, the one or more pathways can be created by a shape of the back inner shoe layer **520**. For example, the back inner shoe layer **520** can include a curved portion **524** and one or more support walls (e.g., support walls **522**, **526**, **528**). The one or more support walls can ensure that paths for air flow are not collapsed during normal usage (e.g., a user walking). In some embodiments, the curved portion **524** can be a curvature similar to the outer shoe layer **510**. The curvature can allow for a heel of a foot to be placed inside of the curved portion **524**.

The curved portion **524** can be coupled to a first support wall **522** at a first end of the curved portion **524**. The first support wall **522** can also be coupled to the outer shoe layer **510**. In some embodiments, the first support wall **522** can create separation between the first curved portion **524** and the outer shoe layer **510** to provide a first pathway for air. In some embodiments, the first support wall **522** can close off the first pathway from the rest of the inside of the outer shoe layer **510** such that air that flows through the first pathway can be directed below the outer shoe layer **510**. The curved portion **524** can also be coupled to a third support wall **528** at an opposite end of the curved portion **528**, opposite of where the curved portion **524** is coupled to the first support wall **522**. One of ordinary skill in the art will appreciate that the third support wall **528** may not be exactly opposite of the first support wall **522**, and may be approximately opposite. A second pathway for air can be created between the second curved portion **528** and the outer shoe layer **510**. The second pathway can be closed off from the rest of the footwear by the third support wall **528**. The curved portion **524** can also be coupled to a second support wall **526** at a second location of the curved portion **545** (e.g., between the first end and the second end of the curved portion **524**, such as half way between or other percentage). The second support wall **526** can also be coupled to the outer shoe layer **510**. The second support wall **526** can perform similar functions to the first support wall **522**. The second support wall **526** can separate the first pathway from the second pathway. In some embodiments, the back inner shoe layer **520** may not include the second support wall **526** such that the first pathway and the second pathway are combined into a single pathway between first support wall **522** to third support wall **528**.

In other embodiments, the back inner shoe layer **520** can include straight portions that can be bent by a user's foot to form a curved portion. In such embodiments, the back inner shoe layer **520** would not include a curved portion unless force from a user's foot is applied to the back inner shoe layer **520**. To facilitate bending, the back inner shoe layer **520** can be a flexible material (e.g., plastic, a polymer, or other suitable flexible material) that couples at a first location on the outer shoe layer **510** (near where the first support wall **522** couples to the outer shoe layer **510**), extends straight from the first location to a second location on the outer shoe layer **510**, couples to the second location (near where the second support wall **526** couples to the outer shoe layer **510**), extends straight from the second location to a third location on the outer shoe layer **510**, and couples to the third location (near where the third support wall **529** couples to the outer shoe layer **510**).

In some embodiments, the outer shoe layer **510** can include one or more back holes **541** near the back of the outer shoe layer **510**. The one or more back holes **541** can line up with the one or more pathways to allow for air from outside of the shoe to flow below the outer shoe layer **510** to a location where a movable part (e.g., such as movable part **302** or other movable part described herein) can be located. The air can flow through one or more back holes **541** as illustrated by arrow **542**. The air can continue to flow under the outer shoe layer **510**, as illustrated by arrow **544**, until the air reaches a front end of the outer shoe layer **510**. The area under the outer shoe layer **510**, corresponding to where arrow **544** is located, may include a mechanical ventilation system as described herein. The metical ventilation system may receive air from a direction corresponding to arrow **542** and expel air from a direction corresponding to arrow **546**.

The front end of the outer shoe layer **510** can include one or more front holes **543** to allow for air to flow from under the outer shoe layer **510** (where a movable pump can be located) back into the outer shoe layer **510**. In some examples, a foot of a user can be located over the one or more front holes **543**.

The air can then flow, as illustrated by arrow **548**, above the front inner shoe layer **530**. In some embodiments, the front inner shoe layer **530** can include a curved portion **532** and a support wall **534**. The support wall **534** can be coupled to the outer shoe layer **510**. The support wall **535** can create separation between the front inner shoe layer **530** and the outer shoe layer **510** to create one or more exit pathways for air. A first exit pathway can be to the left of the support wall **534**, between the outer shoe layer **510** and the front inner shoe layer **530**. A second exit pathway can be to the right of the support wall **534**, between the outer shoe layer **510** and the front inner shoe layer **530**. Air can flow through the one or more exit pathways, as illustrated by arrow **550**, and out of the foot opening **515**, as illustrated by arrow **552**. In some embodiments, a middle portion of a user's foot can be located under the front inner shoe layer **530**.

FIG. **5**B is a bottom view of the air vent apparatus **500**, in accordance with an embodiment of the present disclosure. FIG. **5**B illustrates the outer shoe layer **510** as a nontransparent piece, as opposed to semitransparent as in FIG. **5**A. The outer shoe layer **510** includes the one or more back holes **541** located at the back of the outer shoe layer **510**. As described above, the one or more back holes **541** allow air to exit the outer shoe layer **510**. In some embodiments, the air can flow as illustrated by arrows **542**, **544**, **546**, such that the air flows into a mechanical ventilation system (as described herein) by way of arrow **542**, flows through the mechanical ventilation system roughly corresponding to arrow **544**, flows out of the mechanical ventilation system and into a front portion of a footwear in a direction corresponding to arrow **546**, and exits the front portion through one or more exit pathways (as illustrated by arrow **550** in FIG. **5**A). At the arrow **546**, the air can flow into the one or more front holes **543** to refresh an area where a front of portion of a foot of a user would be located.

FIG. **5**C depicts an air intake opening **541** and exhaust openings **543** for an air vent layer, in accordance with an embodiment of the present disclosure. The air vent layer may be on top of an air reservoir, allowing air to pass through opening on the air vent layer to enter and exit the air reservoir. For example, the air intake opening **541** (which may correspond to the one or more back holes **541** depicted in FIG. **5**B) may be located near a back of a piece of footwear. The air intake opening may line up with one or more pathways (e.g., as illustrated by arrow **540** in FIG. **5**A) to allow for air from outside of the piece of footwear to flow into an air reservoir that is used by a mechanical ventilation system. While FIG. **5**C illustrates a single air intake opening, it should be recognized that there may be multiple air intake openings of similar or varying size and/or shape.

The air can continue to flow in the air reservoir until the air reaches the exhaust openings **543**. The air can flow out of one or more of the exhaust openings **543** to refresh an area of the piece of footwear that holds a foot. The exhaust openings **543** are illustrated as varying in intensity in a direction towards a front of the piece of footwear. For example, the exhaust openings furthest from the front are spread wider apart than the exhaust openings closer to the front. In addition, a single exhaust opening that is bigger than other exhaust openings is located closest to the front such that more air is allowed to escape through the single exhaust opening. While FIG. **5**C illustrates exhaust openings of particular size, shape, and configuration, it should be recognized that there may be different sizes, shapes, and configurations used.

FIG. **5**D depicts an air intake opening **541** in a piece of footwear, in accordance with an embodiment of the present disclosure. In FIG. **5**D, the air intake opening **541** is located at the back of the piece of footwear, near where a heel of a user would be located. The air intake opening **541** illustrated in FIG. **5**D may receive air from outside of the piece of footwear to direct to a front portion of the piece of footwear to refresh air located therein.

FIG. **5**E depicts an exhaust tunnel **535** in a piece of footwear, in accordance with an embodiment of the present disclosure. The exhaust tunnel **535** may correspond to the areas on the sides of the support wall **534** illustrated in FIG. **5**A. The exhaust tunnel **535** may be a pathway for air to go from a front portion of the piece of footwear to outside of the piece of footwear. The pathway may be separated into multiple pathways, as illustrated in FIG. **5**E. The multiple pathways may allow the exhaust tunnel **535** to include structural columns to maintain the shape of the exhaust tunnel **535**, even when shoe laces are tied. The exhaust tunnel **535** may be inserted between a foot of a user and a top of the piece of footwear when the foot is inside of the piece of footwear. In other words, the exhaust tunnel **535** may be coupled to an inside of the top of the piece of footwear, as illustrated in FIG. **5**E. It should be recognized that the exhaust tunnel **535** may be made out of any suitable material, including plastic, metal, fabric, or the like.

FIG. **5**F is a perspective view of an exhaust tunnel **534**, in accordance with an embodiment of the present disclosure. The exhaust tunnel **534**, depicted in FIG. **5**F, is longer than it is wide. The length of the exhaust tunnel **534** may allow a pathway to be created from near a front of a piece of footwear to an area where air may flow out of the piece of footwear (e.g., the area may be near a tongue of the piece of footwear). The width of the exhaust tunnel **534** may correspond to a width of the piece of footwear. For example, the exhaust tunnel **534** may be similar width as the piece of footwear. For another example, the exhaust tunnel **534** may be shorter than the width of the piece of footwear.

FIG. **5**G is a front view of an exhaust tunnel **534**, in accordance with an embodiment of the present disclosure. The exhaust tunnel **534**, depicted in FIG. **5**G, has different sized pathways that make up the exhaust tunnel **534**. The size of each pathway may correspond to a foot that would be under the exhaust tunnel **534** when the foot is in a piece of footwear that includes the exhaust tunnel **534**. For example, the exhaust tunnel **534** illustrates that a leftmost pathway is taller than other pathways, a middle pathway is substantially square, and a rightmost pathway is wider than other pathways. In some examples, the size of the different pathways may depend on a shape of the piece of footwear.

FIG. **6** is a side view illustrating an example of a mechanical ventilation system **600**, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **600** can be similar and include any of the components of the mechanical ventilation system **300**, **400**, and/or **500**.

The mechanical ventilation system **600** can further include a sealed foot platform **660**. The sealed foot platform **660** can cover a surface discontinuity, caused by the mechanical ventilation system **600**, where the foot rests. For example, a surface discontinuity can exist at an exhaust opening **618** a front actuator portion **616**, the substantially rigid surface **604**, the rear actuator portion **612**, the back lining **650**, or any other area of the mechanical ventilation system **600** that can cause discomfort for a foot. The sealed foot platform **660** can be implemented with a number of materials, including fabric, flexible plastic material, or other suitable cushioning surface.

FIG. **7** is another example of a mechanical ventilation system **700**, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **700** can include a movable part **702**. The movable part **702** can include a front actuator portion **716** and a rear actuator portion **712** at different locations as compared to the actuators shown in FIGS. **3**A-**3**E. In the example shown in FIG. **7**, the front actuator portion **716** is closer to the foot center; however, the front actuator portion **716** can continue to perform the same function as that performed by the front actuator portion **316** described above with respect to FIG. **3**A-FIG. **3**E. By moving the front actuator portion **716** closer to the middle or arch of a foot, the foot itself can come to rest in a more natural position when the user is standing. For example, the front actuator portion **716** can be positioned under the arch of the foot. The front actuator portion **716** can be positioned so that the front actuator portion **716** can still be lowered by a foot when a step is taken. The locations of actuators **712** and **716** can be modified to be closer to the center of the foot than that shown in FIG. **7**. The locations of the actuators **712** and **716** can depend on the footwear design and application, including the shape of the foot, the use for the footwear, or any other factor.

As also can be seen in FIG. **7**, an intake opening **703** can be provided near a rear actuator portion **712** to allow air to enter an air reservoir **708**. The intake opening **703** can include an air-permeable surface, similar to that described above, to allow air to enter the mechanical ventilation system **700** while providing stability for a foot. The mechanical ventilation system **700** can also include an exhaust opening **718** that is provided at the opposite end of the footwear to allow air to exit the footwear. The exhaust opening **718** can have the same properties and functionality as the exhaust opening **318** of FIG. **3**A-FIG. **3**E, in that it allows air to escape the mechanical ventilation system **700** while also providing stability for the foot.

FIG. **8**A and FIG. **8**B illustrate an example of a lowering depth of a movable part, before and after lowering, in a single direction mechanical ventilation system, in accordance with an embodiment of the present invention. The example illustrates that a lowering depth (d**1**) can be approximately equal to an air reservoir depth (d**2**). The lowering depth can include a height of an actuator that is above a substantially rigid surface. The air reservoir depth can include a distance that a movable part can lower. As can be seen in FIG. **8**A and FIG. **8**B, d**1** can be approximately equal to d**2**. In such an example, in order to increase the volume of air movement, which is a function of d**2**, the height of the actuator that is above the substantially rigid surface can be increased. However, by increasing the height of the actuator that is above the substantially rigid surface, the footwear can become exceedingly tall, unstable, and/or uncomfortable.

FIG. **9**A illustrates an example of a mechanical ventilation system **900** that enhances air flow by taking advantage of parallel air reservoirs, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **900** is shown in a resting position in FIG. **9**A. In the resting position, an elastic element **920** of the mechanical ventilation system **900** can be decompressed. The mechanical ventilation system **900** can provide increased air flow with less lowering depth by utilizing a multi-level design.

The movable part **902** can include an actuator **912**, a top level extension **917**, a middle level extension **918**, and a bottom level extension **919**. However, one of skill in the art will appreciate that the movable part **902** can include more or less extensions that are stacked vertically. By adding multiple levels of extensions, organized vertically, the mechanical ventilation system **900** can decrease a lowering depth **972** (d**1**) of the actuator **912** without linearly losing the amount of air displaced. As shown in FIG. **9**A, a lowering depth **972** (d**1**) of the actuator **912** is equal to each reservoir depth **970**, which are under the top level extension **917**, the middle level extension **918**, and the bottom level extension **919**. The reservoir depth of the top level extension **917**, the middle level extension **918**, and the bottom level extension **919** can be equal to each other, or can be slightly different. By adding three levels of extensions, lowering the movable part **902** by the lowering depth **972** can result in approximately three times the amount of air displaced. In one example, as the actuator **912** is lowered by 1 centimeter, the movable part **902** can compress up to 3 centimeters of air. It can be beneficial to minimize the lowering depth **972** of the actuator **912** to make the footwear more stable and comfortable for the user. The number of extensions that can be included in the footwear can be limited based on the height of the shoe. Each new extension requires an additional amount of height to be added to the mechanical ventilation system **900**.

Each of the extensions (i.e., the top level extension **917**, the middle level extension **918**, and the bottom level extension **919**) can be adjacent to a substantially rigid surface (e.g., substantially rigid surfaces **980**, **981**, **983**). To support each of the substantially rigid surfaces, one or more columns (e.g., a first column **982** and a second column **984**) can be added to the mechanical ventilation system **900** and can attach to each of the substantially rigid surfaces. In some embodiments, a column can be hollow to allow air flow. While FIG. **9**A illustrates two columns, one of skill in the art will appreciate that there may be more or less columns, the columns may be offset more or less than that shown, or there may be no columns. In examples in which there are no columns, the substantially rigid surfaces can be attached to another part of the mechanical ventilation system **900**, such as a vertical column **986** (located to the right of the movable part **902**) or a side wall of the footwear. Attaching the substantially rigid surfaces to the side wall can eliminate the need for columns, and thus reduce the number of elements taking up space in the air reservoirs. In some embodiments, only a single substantially rigid surface (e.g., the substantially rigid surface **980**) may be included in the mechanical ventilation system **900**. In such embodiments, substantially rigid surfaces **981**, **983** may not be included.

In some embodiments, the actuator **912** can include a vertical hollow region **990**, a first horizontal hollow region **992**, and a second horizontal hollow region **994**. The hollow regions **990**, **992**, and **994** can allow fresh air to flow from an area above the actuator **912** to one or more of the air reservoirs located below each of the top level extension **917**, the middle level extension **918**, and the bottom level extension **919**. However, one of skill in the art will appreciate that the form of the hollow regions **990**, **992**, **994** can be different than that illustrated in FIG. **9**A. For example, the hollow regions **990**, **992**, **994** can be a straight path from the top of the actuator **912** to the air reservoirs located below each of the top level extension **917**, the middle level extension **918**, and the bottom level extension **919**. In some examples, the hollow regions **990**, **992**, **994** can be narrower or wider than that shown. In some examples, the hollow regions **990**, **992**, **994** do not lead to the top of the actuator **912**. For example, the hollow regions **990**, **992**, **994** can lead horizontally through the actuator **912**, providing air flow from the area including the vertical column **986**. In such an example, instead of having a vertical hollow region **990**, the first horizontal hollow region **992** and the second horizontal hollow region **994** would extend all the way to the vertical column **986**. In such an example, the vertical column **986** can allow air to flow through it, or there can be some distance between the vertical column **986** and the actuator **912** to allow air to flow into the hollow regions **992** and **994**. The precise positioning of the hollow regions **990**, **992**, **994** can be anywhere in the mechanical ventilation system **900** that facilitates the addition of fresh air into the air reservoirs below the top level extension **917**, the middle level extension **918**, and/or the bottom level extension **919**.

FIG. **9**B illustrates an example of the mechanical ventilation system **900** after the movable part **902** is lowered down. In such an example, the elastic element **920** can be compressed. The movable part **902** can be lowered down when the user steps on the actuator **912** (e.g., when the user takes a step). When the movable part **902** is lowered, the vertical hollow region **990** can be closed off by a foot bed **930**, facilitating a one-way air flow through the system into the air reservoirs under each of the top level extension **917**, the middle level extension **918**, and/or the bottom level extension **919**. Each of the extensions can lower the full distance of the reservoir depth **970**. The lowering can force fresh air out of an exhaust opening **910** and provide ventilation to wherever the exhaust opening **910** leads, such as a front portion of a foot. In some examples, the exhaust opening **910** can include an air-penetrable surface, as described above.

FIG. **10** illustrates an example of a mechanical ventilation system **1000**, which enhances air flow by taking advantage of parallel air reservoirs, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **1000** can include a movable part **1002**. The movable part **1002** can create parallel air reservoirs that allow a depression depth **1070** of the movable part **1002** to displace air corresponding to approximately three times the depression depth **1070**. The increase in air displacement can be because each air reservoir can displace a volume of air corresponding to the depression depth **1070**.

To facilitate the parallel air reservoirs, the movable part **1002** can include one or more actuators (e.g., a front actuator portion **1016** and a rear actuator portion **1012**). The rear actuator portion **1012** can include a vertical hollow region **1090**, a first horizontal region **1092**, and a second horizontal region **1094**. The hollow regions **1090**, **1092**, and **1094** can operate as described above in FIGS. **9**A and **9**B. For example, the hollow regions **1090**, **1092**, and **1094** can provide air to air reservoirs.

In some embodiments, the front actuator portion **1016** and the rear actuator portion **1012** can be connected to each other by one or more extensions (e.g., a bottom level extension **1019**, a middle level extension **1018**, and a top level extension **1017**). In some embodiments, a top of the front actuator portion **1016** and/or a top of the rear actuator portion **1012** can be level with the top level extension **1017**, as shown in FIG. **10**. In such embodiments, a substantially rigid surface above the top level extension **1017** can be removed from the mechanical ventilation system **1000** such that a foot of a user can rest on the movable part **1002** rather than the substantially rigid surface. In other embodiments, the top of the front actuator portion and/or the top of the rear actuator portion can raise above the top level extension, as shown in FIG. **9**A. In some embodiments, the mechanical ventilation system **1000** can include one or more substantially rigid surfaces (e.g., middle substantially rigid surface **1081** and lower substantially rigid surface **1085**).

Above each substantially rigid surface **1081** and **1085** can be an air reservoir, as discussed above. The air reservoir can be between a substantially rigid surface and an extension, such as between substantially rigid surface **1081** and top level extension **1017**. In some embodiments, the air reservoir can maintain maximum volume when the movable part **1002** is being pushed in an upward direction. In some embodiments, the movable part **1002** can be pushed in an upward direction by one or more elastic elements (e.g., elastic element **1020**). In some embodiments, air is pushed out of the air reservoirs when the one or more extensions are pushed toward the substantially rigid surfaces.

In some embodiments, the front actuator portion **1016** can include a top horizontal region **1093** and a bottom horizontal region **1095**. The top horizontal region **1093** can provide a path for air to exit from an air reservoir that is under the top level extension **1017** when the movable part **1002** is lowered by a foot of a user. The bottom horizontal region **1095** can provide a path for air to exit from an air reservoir under the middle level extension **1081** when the movable part **1002** is lowered by the foot of the user. The amount of air displaced by each extension, which exits through the horizontal regions **1093**, **1095**, can correspond to a depression depth **1070**. The depression depth **1070** can be a distance that the movable part **1002** can move downward before at least one of the extensions **1017**, **1018** makes contact with the substantially rigid surfaces **1081**, **1085** respectively. The front actuator portion **1016** can facilitate a more thorough compression of the air reservoir when the movable part is compressed/depressed. In some examples, the second actuator can reduce an amount of tilt of the movable part **1002** when the actuators are compressed or depressed. The tilt can be present when a movable part only includes one actuator (e.g., a rear actuator portion). In such examples, the side opposite of the one actuator (which can extend along an air reservoir) might not have an element to push the side opposite of the one actuator down without a second actuator. Also, the first and second actuator can work together to perform peristaltic compression, where the air is pushed from the back to the front when the user is walking.

FIG. **11**A is a side view illustrating an example of a mechanical ventilation system **1100** for footwear in a raised position, in accordance with an embodiment of the present disclosure. Similar to mechanical ventilation systems discussed above, the mechanical ventilation system **1100** can include a movable part **1102**. The movable part **1102** can include a front actuator portion **1116**, a rear actuator portion **1112**, and an extension **1114**.

However, unlike the embodiments described above, the front actuator portion **1116** and the rear actuator portion **1112** can protrude from the movable part **1102** in a direction toward a ground **1131**. By protruding down rather than up, the front actuator portion **1116** and the rear actuator portion **1112** can be moved when they are in contact with the ground **1131** rather than when the actuators are in contact with a foot. In some embodiments, a sole **1130** of the footwear can include one or more holes so that the actuators can make contact with the ground **1131**. In some embodiments, the actuators can protrude farther down than the sole **1130**. By protruding farther than the sole **1130**, the actuators can be pushed in an upward direction by the ground **1131** until the actuators are on the same level or plane as the sole **1130**.

The movable part **1102** can be continuously pushed toward the ground **1131** by one or more elastic elements (e.g., elastic elements **1120**, **1124**) with a force that allows the extension **1114** to be flush with a top portion of the sole **1130**; however, the force should not be so much as for the user to feel the movable part **1102** when the foot of the user is on the ground **1131**. Because gravity is also pushing the movable part **1102** toward the ground, the elastic elements **1120**, **1124** can exert a force that includes gravity. In some embodiments, the extension **1114** can be pushed downward, by gravity and/or one or more elastic elements, such that the extension **1114** is in contact with the top portion of the sole **1130**. The elastic elements **1120**, **1124** can be coupled to a substantially rigid surface **1104**. The substantially rigid surface **1104** can also provide support for a foot of a user to rest on. An area between the substantially rigid surface **1104** and the extension **1114** can be an air reservoir, which can hold air.

In some embodiments, an intake opening **1103** can be provided near a back side of the air reservoir to allow air to enter the air reservoir. The intake opening **1103** can include an air-permeable surface, similar to that described above, to allow air to enter the air reservoir while providing stability for a foot. The mechanical ventilation system **1100** can also include an exhaust opening **1118** that is provided at the opposite end of the air reservoir to allow air to exit the air reservoir. The exhaust opening **1118** can have the same properties and functionality as the exhaust opening **318** of FIG. **3**A-FIG. **3**E, in that it allows air to escape the mechanical ventilation system **1100** while also providing stability for the foot.

FIG. **11**B is a side view illustrating the mechanical ventilation system **1100** in a lowered position, in accordance with an embodiment of the present disclosure. In particular, FIG. **11**B illustrates when the front actuator portion **1116** and the rear actuator portion **1112** are in contact with the ground **1131**. In such an example, the movable part **1102** can be pushed upward by the ground **1131** such that the air reservoir between the movable part **1102** and the substantially rigid surface **1104** is substantially eliminated, causing air to flow out of the exhaust opening **1118**.

In some embodiments, when the movable part **1102** is pushed upward by the ground **1131**, the elastic elements **1120**, **1124** can be compressed. The elastic elements **1120**, **1124** can be compressed without a foot of a user noticing the compression. In other embodiments, as described above, the mechanical ventilation system **1100** might not include the elastic elements **1120**, **1124**. In such embodiments, the movable part **1102** can be influenced by gravity.

In embodiments with the movable part **1102** facing in a downward direction, as shown in FIGS. **11**A and **11**B, the movable part **1102** can still operate similarly to FIGS. **3**A-**3**E during a stepping motion. A difference can include that a force is being applied to the movable part from the ground **1131** rather than from a foot of a user.

FIG. **12** is a side view illustrating an example of a mechanical ventilation system **1200** for footwear in a lowered position, in accordance with an embodiment of the present disclosure. The mechanical ventilation system **1200** can perform similarly to FIGS. **11**A and **11**B. However, rather than the sole **1130** being flat, as shown in FIGS. **11**A and **11**B, a front actuator portion **1216** can fit through a first open hole in a flexible sole **1230**, and a rear actuator portion **1212** can fit through a second open hole in the flexible sole **1230**. In some examples, the flexible sole **1230** can couple to one or more actuators to make the flexible sole **1230** waterproof, or at least water resistant. In particular, a first portion and a second portion of the flexible sole **1230** that are on each side of the front actuator portion **1216** can be coupled, or bonded such as to resist water, to the front actuator portion **1216** to create a seal between the flexible sole **1230** and the front actuator portion **1216**. In addition, a first portion and a second portion of the flexible sole **1230** that are on each side of the rear actuator portion **1212** can be coupled, or bonded such as to resist water, to the rear actuator portion **1212** to create a seal between the flexible sole **1230** and the rear actuator portion **1212**.

To facilitate movement of a movable part **1202**, which includes the front actuator portion **1216** and the rear actuator portion **1212**, the flexible sole **1230** can be a flexible, or semi-rigid, material such as a thermoplastic elastomer (e.g., NinjaFlex) or other suitable material. In such embodiments, because of the flexibility of the flexible sole **1230**, portions of the flexible sole **1230** near the front actuator portion **1216** and the rear actuator portion **1212** can move with the actuators **1216**, **1212**. In some embodiments, the front actuator portion **1216**, the rear actuator portion **1212**, and the flexible sole **1230** can comprise the same material or can be separate materials.

In some embodiments, the mechanical ventilation system **1200** can include one or more elastic elements (e.g., elastic elements **1220**, **1224**). In other embodiments, the mechanical ventilation system **1200** might not include one or more elastic elements because the flexible sole **1230** can perform a similar function of opening an air intake opening and closing an air exhaust opening of an air reservoir located between a movable part **1202** and a substantially rigid surface **1304**.

FIG. **13**A is a side view illustrating an example of a mechanical ventilation system **1300** for footwear in a raised position, in accordance with an embodiment of the present disclosure. Rather than including a separate movable part (as described in the embodiments above), the mechanical ventilation system **1300** can incorporate the movable part into a sole (which can include a front sole portion **1332**, a middle sole portion **1334**, back sole portion **1336**, a front actuator portion **1316**, and a rear actuator portion **1312**). In such embodiments, even though the movable part is not a separate piece, the functionality can remain similar. For example, an air reservoir can be created between the sole and a substantially rigid surface **1304** while the footwear is off a ground **1331**. In such an example, a portion of the sole can function as described above for the movable part.

In some embodiments, a flexibility of the sole can vary along a length of the sole. For example, the middle sole portion **1334**, between the front actuator portion **1316** and the rear actuator portion **1312**, can be rigid, similar to the movable part mentioned above. In addition, the front sole portion **1332** of the sole, in front of the front actuator portion **1316** (toward a front of the footwear) and the back sole portion **1336**, behind of the rear actuator portion **1312** (toward a back of the footwear), can be flexible to allow the sole to move as the movable part would move in FIG. **12**. A benefit of incorporating the movable part into the sole is that the air reservoir between the sole and the substantially rigid surface **1304** can be enlarged as compared to when a movable part is also included.

Again, the mechanical ventilation system **1300** illustrates one or more elastic elements (e.g., elastic elements **1324**, **1320**); however, the mechanical ventilation system **1300** can operate without an elastic element.

FIG. **13**B is a side view illustrating the mechanical ventilation system **1300** in a lowered position, in accordance with an embodiment of the present disclosure. As can be seen, the front sole portion **1332** of the sole, which is in front of the front actuator portion **1316** (toward a front of the footwear), is flexible enough to bend such that a front region of the front sole portion **1332** is touching the ground **1331** while a back region of the front sole portion **1332** coupled to the front actuator portion **1316** is not touching the ground **1331**. The back sole portion **1336** of the sole **1330**, which is behind the rear actuator portion **1312** (toward a back of the footwear), can operate similarly as the front sole portion **1332**, with a back region of the back sole portion **1336** touching the ground **1331** while a front region of the back sole portion **1336** coupled to the rear actuator portion **1312** is not touching the ground **1331**.

In some embodiments, the middle sole portion **1334** of the sole that is between the front actuator portion **1316** and the rear actuator portion **1312** can be rigid, similar to the movable part discussed above. By being rigid, the middle sole portion **1334** can eliminate an air reservoir between the sole and a substantially rigid surface **1304** when the mechanical ventilation system **1300** is in the lowered position, in which case the middle sole portion **1334** is raised in an upward direction toward the substantially rigid surface **1304**. In some embodiments, the front actuator portion **1316** and the rear actuator portion **1312** can protrude from the sole a length equal to a height of the air reservoir or other suitable height.

FIG. **14**A is a side view illustrating an example of a mechanical ventilation system **1400** for footwear in a first (raised) position, in accordance with an embodiment of the present disclosure. In such an example, rather than having a front actuator portion and a rear actuator portion that protrude from a sole **1430** (as in some embodiments described above), the sole **1430** can be flexible such that an air reservoir between the sole **1430** and a substantially rigid surface **1404** can be filled and collapsed as if there were the front actuator portion and the rear actuator portion. In some embodiments, the sole **1430** can retain a convex shape when the shoe is lifted up in the first (raised) position. The convex shape can allow an increase in volume of the air reservoir. In some embodiments, a selective portion of the substantially rigid surface **1404** can be made semi-flexible to further increase or decrease air volume in an air reservoir when a user lifts up or steps on the footwear. If the sole **1430** is flexible and the substantially rigid surface **1404** is also flexible, the air reservoir can be compressed on top and bottom so that both parts share a portion of the vertical travel or deformation, and also the mechanical stress associated with the deformation of the flexible part.

In some embodiments, one or more elastic elements (e.g., elastic elements **1420**, **1424**) can be coupled to the sole **1430** and the substantially rigid surface **1404**. The one or more elastic elements can maintain the air reservoir when the footwear is not on the ground by separating the sole **1430** from the substantially rigid surface **1404**. In some embodiments, the one or more elastic elements can also maintain a shape of the sole **1430**. For example, the one or more or more elastic elements can ensure that the sole **1430** does not excessively round underneath the footwear. In other embodiments, the mechanical ventilation system **1400** might not include the one or more elastic elements. In such embodiments, a motion of the sole **1430** can be influenced by gravity.

In some embodiments, the mechanical ventilation system **1400** can be combined with the multilayer design in FIGS. **9**A and **9**B.

FIG. **14**B is a side view illustrating the mechanical ventilation system **1400** in a second position, in accordance with an embodiment of the present disclosure. The second position represents a foot of a user heel striking a ground **1431**. As a heel of the foot strikes the ground **1431**, the sole **1430** can make contact with the ground **1431**. The contact with the ground **1431** can cause an intake opening **1403** to be substantially closed off, forcing air through an air reservoir located between the sole **1430** and a substantially rigid surface **1404** upon which the foot rests. In some embodiments, the heel strike can cause a portion near the intake opening **1403** of the air reservoir to be eliminated, causing air to flow toward, and/or out of, the exhaust opening **1418**.

In embodiments that include one or more elastic elements (e.g., elastic elements **1420**, **1424**), the heel strike can cause the elastic element **1420** to substantially compress, as shown in FIG. **14**B. The elastic element **1424** can remain substantially uncompressed when the heel, and not the rest of the footwear, is striking the ground **1431**. In other embodiments, the mechanical ventilation system **1400** can allow gravity to manipulate the sole **1430** without the use of one or more elastic elements.

FIG. **14**C is a side view illustrating the mechanical ventilation system **1400** in a third (lowered) position, in accordance with an embodiment of the present disclosure. In such a position, a sole **1430** can be resting, or touching, the ground **1431**. In some embodiments, the sole **1430** can conform to the ground **1431** due to a flexibility of the sole **1430**. As shown in FIG. **14**C, the one or more elastic elements (e.g., elastic elements **1420**, **1424**) can be compressed when the mechanical ventilation system **1400** is in the third position, allowing the sole **1430** and the substantially rigid surface **1404** to come into contact. In such embodiments, the air reservoir located between the sole **1430** and the substantially rigid surface **1404** can be reduced or temporarily eliminated, which expels any remaining air in the air reservoir through an exhaust opening **1418**.

FIG. **14**D is a side view illustrating the mechanical ventilation system **1400** in a fourth position, in accordance with an embodiment of the present disclosure. The fourth position includes a position in which the foot is raised from the ground **1431**. In the fourth position, the sole **1430** and the substantially rigid surface **1404** begin to separate as the one or more elastic elements (e.g., elastic elements **1420**, **1424**) exert force on the sole **1430**, allowing the air reservoir between the sole **1430** and the substantially rigid surface **1404** to at least partially fill with air entering through the intake opening **1403**. In some embodiments, an exhaust opening **1418** can be closed off while in the fourth position. When the exhaust opening **1418** is closed off, air collected in the air reservoir through the intake opening **1403** is not allowed to escape through the exhaust opening **1418**.

In some embodiments, at least a portion of the sole **1430** can maintain contact with the ground **1431** when a heel of the foot has been picked up by a user. As the user then raises the front of the foot, the mechanical ventilation system **1400** returns to the first (raised) position, where the entire foot is lifted as shown in FIG. **14**A, and the reservoir is fully opened to allow air to fill the reservoir. FIGS. **14**A, **14**B, **14**C, and **14**D together illustrate a peristaltic compression of the air reservoir by the flexible sole to move the air from the intake to the exhaust, to ventilate the shoe with fresh air when the user is walking or running.

FIG. **15**A is a side view illustrating an example of a mechanical ventilation system **1500** for footwear in a raised position, in accordance with an embodiment of the present disclosure. Rather than a sole being semi-flexible, a sole **1530** of the mechanical ventilation system **1500** can be attached to footwear using sidewall connectors **1533**, **1535**. The sidewall connectors **1533**, **1535** can be vertically flexible or semi flexible. The sidewall connectors can be located at a front of the footwear, a rear of the footwear, a side of the footwear, any combination thereof, or any other suitable location of the footwear.

In some embodiments, the sole **1530** can be substantially rigid. The sole **1530** can be coupled to one or more elastic elements (e.g., elastic elements **1524**, **1520**). The one or more elastic elements can also be coupled to a substantially rigid surface **1504**. The substantially rigid surface **1504** can provide support for a foot of a user, as described herein.

In some embodiments, an air reservoir can be created between the substantially rigid surface **1504** and the sole **1530**. While in the raised position, the mechanical ventilation system **1500** can allow air to fill the air reservoir through an intake opening **1503**. In addition, air can flow from the air reservoir through an exhaust opening **1518**.

FIG. **15**B is a side view illustrating the mechanical ventilation system **1500** in a second position, in accordance with an embodiment of the present disclosure. In the second position, a user can drop a back portion of the foot to a ground **1531**. By dropping the foot, the mechanical ventilation system **1500** can substantially block off an intake opening **1503** such that new air is closed off from entering the air reservoir. In addition, air in the air reservoir can be pushed toward and out of an exhaust opening **1518**. In some embodiments, a rear sidewall connector **1535** can compress in the second position. In such embodiments, a forward sidewall connector **1533** can remain substantially uncompressed.

FIG. **15**C is a side view illustrating the mechanical ventilation system **1500** in a third (lowered) position, in accordance with an embodiment of the present disclosure. In the third position, both a rear sidewall connector **1535** and a forward sidewall connector **1533** can be compressed. When the sidewall connectors **1533**, **1535** are compressed, the sole **1530**, which is coupled to the sidewall connectors **1533**, **1535**, can be pushed closer to the substantially rigid surface **1504**. In being pushed closer to the substantially rigid surface **1504**, the sole **1530** can eliminate a portion of an air reservoir that is between the sole **1530** and the substantially rigid surface **1504**. When the air reservoir is partially eliminated, air can be pushed from a back of the footwear, near an intake opening **1503**, toward and out of an exhaust opening **1518**.

In some embodiments, the sole **1530** can be pushed toward the substantially rigid surface **1504** by the ground **1531**. In particular, the force of the footwear and the user's weight against the ground can compress the sidewall connectors **1533**, **1535** such that the sole **1530** is pushed toward the substantially rigid surface **1504**. In some embodiments, a foot of the user can still rest on the substantially rigid surface **1504**.

FIG. **15**D is a side view illustrating the mechanical ventilation system **1500** for footwear in a fourth position, in accordance with an embodiment of the present disclosure. In the fourth position, a heel of a foot can be lifted such that a rear sidewall connector **1535** is at least partially uncompressed. In such an example, the air reservoir between a sole **1530** and the substantially rigid surface **1504** is enlarged, allowing air to flow in through the intake opening **1503**.

In some embodiments, the forward sidewall connector **1533** can be compressed when the mechanical ventilation system **1500** is in the fourth position. The forward sidewall connector **1533** can cause an exhaust opening **1518** to be substantially closed off to the air reservoir, allowing air to remain in the air reservoir without escaping through the exhaust opening **1518**.

FIG. **16** is a side view illustrating another example of a mechanical ventilation system **1600** for footwear that combines other embodiments, in accordance with an embodiment of the present disclosure. An advantage of combining a flexible sole with a flexible sidewall is to share the stress caused by the flexible sole. For example, a flexible sole connected to a rigid sidewall can induce a lot of stress on the sole region that is connected to the rigid sidewall. The stress can be caused because the sole must bear all of the stress in such situations. If the side wall is also flexible, then it can be designed to relieve the stress caused by the flexible sole. In some examples, the sidewall and the sole can be one flexible piece, such that there is no clear distinction between the sidewall and the sole.

The mechanical ventilation system **1600** can include embodiments described in FIGS. **14**A-**14**D and **15**A-**15**D. For example, the mechanical ventilation system **1600** can include a flexible sole **1630**. The flexible sole **1630** can function as a movable part would during a walking motion, as described with FIGS. **14**A-**14**D.

The mechanical ventilation system **1600** can also include a front sidewall connector **1633** and a back sidewall connector **1635**. In other embodiments, the sidewall connectors can be located in the front of the footwear, the back of the footwear, the side of the footwear, any combination thereof, or other suitable location. The sidewall connectors can be flexible or semi-flexible. By adding the two embodiments together, the mechanical ventilation system **1600** can obtain additional compression and expansion of an air reservoir between the flexible sole **1630** and a substantially rigid surface **1604**.

FIG. **17** is a side view illustrating another example of a mechanical ventilation system **1700** for footwear with alterations to a sole **1730**, in accordance with an embodiment of the present disclosure. While the alterations to the sole **1730** are shown using a mechanical ventilation system similar to the mechanical ventilation system **1600**, a person of ordinary skill in the art will recognize that the alterations can be made to any mechanical ventilation system described herein.

In some embodiments, the sole **1730** can include one or more protective regions **1739**. The one or more protective regions **1739** can be made to be thicker or extended over portions of the sole **1730** that are thin and/or flexible. In some embodiments, the one or more protective regions **1739** can be coupled to the sole **1730** in places that are not thin so as to keep the thin regions flexible. By including the one or more protective regions **1739**, the one or more protective regions **1739** can be worn down instead of the sole **1730**. In some embodiments, the protective regions **1739** can be made with a more durable material (e.g., an engineering plastic such as polyether ether ketone (PEEK), a ceramic such as alumina, or other durable material). In some embodiments, the protective regions can be made to be user replaceable.

In some embodiments, the sole **1730** can include sidewall covers (e.g., front sidewall cover **1737** and back sidewall cover **1738**). The sidewall covers can protect a sidewall connector (e.g., front sidewall connector **1733** and back sidewall connector **1735**) from wear. In such examples, the sole **1730** can be more prone to wear because the sole **1730** is made flexible. The advantage of the various covers is to protect the flexible sole. The sole can be flexible not only by a choice of material, but also by making the material relatively thin.

FIG. **18** is a bottom view illustrating an example of compressible elements for a mechanical ventilation system **1800**, in accordance with an embodiment of the present disclosure. The mechanical ventilation system includes an outer shoe layer **1810** (as discussed above), a vertical wall **1843** (to create an air reservoir), and a flexible shoe bottom (not shown). The three components mentioned can be coupled together to create a footwear. For example, the upper part **1810** can be blued onto the vertical wall **1843** and the vertical wall **1843** can be glued onto the flexible shoe bottom layer. In one illustrative example, the vertical wall **1843** can be 8 millimeters tall. In such an example, the air reservoir can include the entire shoe bottom inside of the 8 mm tall vertical wall **1843**.

As described above, the outer shoe layer **1810** can include one or more back holes **1841** and one or more front holes **1843**. The mechanical ventilation system **1800** can further include one or more elastic elements **1820** (e.g., compressible components to facilitate movement of the flexible shoe bottom). As can be seen in FIG. **18**, the one or more elastic elements **1820** can be located on the underside, or bottom, of a foot bed where a foot of the user rests their foot. A person of ordinary skill in the art will recognize that FIG. **18** is only an example of a configuration of the one or more elastic elements **1820**, and that the one or more elastic elements **1820** can be arranged in any way on the foot bed.

In one illustrative example, an elastic element can be a leaf spring (as shown in FIG. **18**). An advantage of the leaf spring is its low profile thickness when fully compressed. In some examples, the leaf springs can be made of Beryllium Copper. The Beryllium Copper can allow the leaf springs to retain springiness after many cycles of compression and relaxation. However, a person of ordinary skill in the art will recognize that the elastic elements can be different materials and/or different types.

In the foregoing specification, aspects of the invention are described with reference to specific embodiments thereof, but those skilled in the art will recognize that the invention is not limited thereto. Various features and aspects of the above-described invention may be used individually or jointly. Further, embodiments can be utilized in any number of environments and applications beyond those described herein without departing from the broader spirit and scope of the specification. The specification and drawings are, accordingly, to be regarded as illustrative rather than restrictive.

In the foregoing description, for the purposes of illustration, methods were described in a particular order. It should be appreciated that in alternate embodiments, the methods may be performed in a different order than that described.

Where components are described as being configured to perform certain operations, such configuration can be accomplished, for example, by designing electronic circuits or other hardware to perform the operation, by programming programmable electronic circuits (e.g., microprocessors, or other suitable electronic circuits) to perform the operation, or any combination thereof.

In addition, other components may be added to, or removed from, the described systems. Accordingly, other implementations are within the scope of the following claims.

Where components are described as being configured to perform certain operations, such configuration can be accomplished, for example, by designing the components to operate in a certain way when an action is performed, such as when a user takes a step.

While illustrative embodiments of the application have been described in detail herein, it is to be understood that the inventive concepts may be otherwise variously embodied and employed, and that the appended claims are intended to be construed to include such variations, except as limited by the prior art.

What is claimed is:

1. A mechanical ventilation system for footwear, comprising: a substantially rigid surface configured to support at least a portion of a foot; a movable part comprising:

- a front actuator portion positioned at a front portion of the footwear, the front actuator portion being compressible in a first direction and extending at least partially through a first opening in the substantially rigid surface;
- a rear actuator portion positioned at a rear portion of the footwear, the rear actuator portion being compressible in the first direction and extending at least partially through a second opening in the substantially rigid surface; and
- an extension piece located at least partially under the substantially rigid surface, the extension piece connecting the front actuator portion to the rear actuator portion;
- an elastic element coupled to the movable part, the elastic element being configured to push the front actuator portion and the rear actuator portion in a second direction; and
- an air reservoir including an air intake opening and an air exhaust opening;
- wherein when the rear actuator portion is compressed in the first direction, the extension piece overcomes a force of the elastic element to cause the extension piece to move in the first direction, forcing air out of the air exhaust opening of the air reservoir.

2. The mechanical ventilation system of claim **1**, wherein the air reservoir is defined by the substantially rigid surface and a sole of the footwear.

3. The mechanical ventilation system of claim **1**, wherein a repetitive compression and decompression of the front actuator portion and the rear actuator portion ventilates a foot compartment of the footwear by a flow of air into the air intake opening and out of the air exhaust opening.

4. The mechanical ventilation system of claim **1**, wherein when the rear actuator portion is compressed in the first direction, the front actuator portion is moved in the second direction.

5. The mechanical ventilation system of claim **1**, wherein when the front actuator portion is compressed in the first direction, the extension piece overcomes a force of the elastic element to cause the rear actuator portion to move in the second direction, allowing air to enter into the air intake opening of the air reservoir.

6. The mechanical ventilation system of claim **5**, wherein the second direction is an upward direction, the elastic element being configured to raise the front actuator portion and the rear actuator portion in the upward direction.

7. The mechanical ventilation system of claim **6**, wherein the first direction is a downward direction.

8. The mechanical ventilation system of claim **1**, wherein when the rear actuator portion is compressed in the first direction, the front actuator portion is compressed in the first direction.

9. The mechanical ventilation system of claim **1**, wherein the movable part is configured to allow air to enter into the air intake opening of the air reservoir when the front actuator portion and the rear actuator portion are pushed in the second direction by the elastic element.

10. The mechanical ventilation system of claim **1**, wherein the elastic element includes at least two elastic elements.

11. The mechanical ventilation system of claim **1**, wherein the elastic element includes one or more springs.

12. The mechanical ventilation system of claim **1**, wherein a portion of a sole of the footwear is flexible and configured to be deformable by a foot.

13. The mechanical ventilation system of claim **1**, wherein the air exhaust opening includes at least one air-permeable surface.

14. The mechanical ventilation system of claim **1**, wherein the air exhaust opening includes at least one open orifice.

15. The mechanical ventilation system of claim **1**, wherein the air exhaust opening is a hollow conduit structure leading from a front opening of the air reservoir via a foot compartment of the footwear to outside of the footwear.

16. The mechanical ventilation system of claim **1**, wherein the air intake opening includes at least one air-permeable surface.

17. The mechanical ventilation system of claim **1**, wherein the air intake opening includes at least one open orifice.

18. The mechanical ventilation system of claim **1**, wherein the air intake opening is a hollow conduit structure leading from a rear opening of the air reservoir to outside of the footwear.

19. The mechanical ventilation system of claim **1**, wherein the second opening in the substantially rigid surface includes the air intake opening.

20. The mechanical ventilation system of claim **1**, wherein the first opening in the substantially rigid surface includes the air exhaust opening.

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